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RAINFALL AND CROPPING PATTERNS

Volume III

BIHAR

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RAINFALL AND CROPPING PATTERNS—STATE SERIES

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RAINFALL AND CROPPING PATTERNS
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Page No.	Paragraph/Table/ Appendix No.	Line	As printed	As desired
1	2	3	4	5
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6	3·9	2	2·3	2·5
6	Table 6	col. 3 row 2	50-6	50-60
7	3·13	2	40 to 60 60	40 to 60
7	3·14 (i)	12-15	On the mean.... 25 to 26°C.	Ranchi and Hazaribagh have average daily minimum temperatures of about 18°C Elsewhere these range from 19 to 21°C.
7	3·14(ii)	13-14 in col 2	The mean annual temperature maximum	The average daily maximum temperature
8	Table 7	Footnote 'ev'	(R)	(r)
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12	4·45	2	Hazaribad	Hazaribagh
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13	4·60	2	10 per cent	15 per cent
14	4·82	Col. 3 row 2 of table	except in Battiah	except in Bettiah
15	4·88	last	$G_3 Cm_4 Cw_4 Cy_4/S_4$-Res	$G_3 Cm_4 Cf_4 Cy_4/S_4$-Rest
16	5·2	7	a State....a national	the State....the national
19	Appendix 2	Col. 1 row 3	$Pd_4 M_4 W Ba_4$	$Pd_4 M_4 W_4 Ba_4$
19	Appendix 2	Col. 1/12	$Pd_3 Pu_4/W_4/M_4/Ju_4$	$Pd_3 Pu_4/W_4$
19	Appendix 2	Rainfall Zone II Rainfall Pattern	$E_4 (B_2 C_2) D_1 K_3$	$E_4 (B_2 C_2) D_1 E_3$
19	Appendix 2	Rainfall Zone IV Rainfall Pattern	$E_4 (A_1 B_1 C_2) E_4$	$E_4 (A_1 B_1 C_2) D_1 E_3$
20	Appendix 2	Col. 1/Rainfall Zone XIV/8	$Pd_2 Pu_4 WM_4/Mt_4$	$Pd_2 Pu_4/W_4 M_4/Mt_4$
20	Appendix 2	Col. 3/7	Garshwa	Garhwa
20	Appendix 2	Rainfall Zone XVII—Rainfall Pattern	$C_1 E_3 (A_4) D_1 E_1$	$C_1 E_3 (A_4) D_1 E_3$
21	Appendix 3	Rainfall Zone II—Rainfall Pattern	$E_4 (B_2 C_2) D_1 E_1$	$E_4 (B_2 C_2) D_1 E_3$
21	Appendix 3	Rainfall Zone III—Rainfall Pattern	$E_4 (A_1 B1) C_2 E_4$	$A_4 (A_1 B_1 C_2) E_4$

CONTENTS

RAINFALL AND CROPPING PATTERNS

BIHAR

INTRODUCTION

1.1 The human population of the country is estimated to rise from the 1971 Census figure of 548 million to 935 million in 2000 AD. This rise calls for increased production. Land resources being limited emphasis has to be placed on increasing productivity per unit area. Temperature and other climatic conditions being favourable for crop production throughout the year over most parts of the country, it is possible to grow more than one crop in a year provided water, the most important input, is available. In some parts of the country, the rainy season is long enough to provide scope for double cropping. This potential is yet to be fully exploited. There is scope for increasing irrigation resources in the country, but our estimates show that the area under irrigation is not expected to be more than 42 per cent of the total cropped area even in 2000 AD. as against 22 per cent in 1970-71. Therefore, judicious utilisation of direct rainfall and irrigation water, singly and in combination, will have to be thought of for increasing production.

1.2 Farming technology has so advanced that it is possible to increase crop yields even under rainfed conditions, but the choice of crops would have to depend upon the amount and distribution of the prevailing rainfall. Additionally, it will be necessary that the maximum possible quantity of rain water is conserved in ponds and pools situated either within the farm area or elsewhere, in soil profiles and underground storages so that the same could be readily used to save crops in times of water stress. Not only in rainbed farming but even under irrigated conditions, one will have to plan for the most economic and efficient use of water so as to derive maximum possible benefit from rainfall and reduce dependence on irrigation. This necessitates a close study of the existing cropping patterns vis-a-vis rainfall patterns aimed at determining the nature of changes needed in the former. The cropping patterns depend primarily on the soil and climatic factors but the evolution of a cropping pattern in course of time is the combined effect of soil, climate, food habits and requirements and economic factors. In the context of increasing production, it is necessary to examine the cropping patterns from a scientific angle and find out possible alternative patterns having higher potential. Accordingly, the Commission undertook a comprehensive study of the rainfall and cropping patterns of the country using taluk or tehsil as unit of area. It covered several other relevant factors such as orography, land use data, human and livestock populations, soil and climate, the object being to make, as far as possible, an integrated assessment.

1.3 Chapter 14 on Rainfall and Cropping Patterns of the Commission's Report presents a consolidated account of the data collected together with analysis of their inter-relationships on all-India basis. In this analysis the Commission has been greatly benefited by the discussions with the concerned officers of State Governments. It was realised that by condensing the vast amount of information collected from each State into the small space of a chapter, many important and peculiar features of individual States were likely to be missed and hence data and analysis of each State have been presented in separate volumes. The manner of presentation is similar to Chapter 14. It has also been considered desirable to include in each State volume the methodology and suggestions for future cropping patterns, which are practically the same as given in Chapter 14.

2 METHODOLOGY

2.1 The chief features of the study are (a) use of taluk or tehsil as unit of area for all basic data and analysis (in the case of Bihar basic data are available according to Sub-divisions and as such, Sub-division is used as the unit of area); (b) introduction of coded numerical forms to express patterns of distribution of monthly rainfall throughout the year, crops and livestock; (c) inclusion of information on orography, temperature, evapotranspiration, rainfall, soil, irrigation, land use, human and livestock populations and yield performance of crops, all of which influence in different ways and degrees the cropping patterns of a place and (d) presentation of coded information on rainfall, crops and livestock on 1 : 1 million scale maps.

Rainfall Patterns

2.2 A major feature of Indian rainfall is that the Southwest monsoon season (June to September) accounts for 70 to 95 per cent of the annual rainfall throughout the country except in the south east peninsula and Kashmir and adjoining hill areas. The monsoon as well as the annual rainfall show large fluctuations from year to year but, as stated in Chapter 13 on Climate and Agriculture, there is no significant

evidence of any trend or periodicity in either of them. Considered in relation to crop production, the total annual or seasonal rainfall does not have much significance and what is important is its distribution during the period of growth of different crops. A relevant question, therefore, is whether rainfall should be examined on a weekly, fortnightly or monthly basis. The coefficient of variation (CV) of monthly rainfall is as high as 40-50 per cent even in the rainiest month of July over most of the central, northern and eastern India. In the south excluding the west coast, CV is higher and varies from 60 to 100 per cent. The variability of weekly or fortnightly rainfall being still greater, makes the use of either of them undependable as indicators of rainfall distribution. For a macro-study like the present, monthly rainfall data which are more dependable and also the most convenient to handle have been used.

2.3 In order to relate crop production with rainfall, certain norms have to be assumed depending on the duration of the crops and their water requirements. On the basis of available information and the fact that most crops mature in about 90 days, the following broad norms have been drawn up :

(i) Rainfall greater than 30 cm per month (cm pm) for at least three consecutive months would be suitable for a crop like paddy whose water need is very high.

(ii) 20-30 cm pm for not less than three consecutive months would be suitable for crops whose water need is high but less than that of paddy, for example, maize and black gram.

(iii) 10-20 cm pm for at least three consecutive months would be suitable for crops requiring much less water, e.g., bajra and small millets.

(iv) 5-10 cm pm for three consecutive months would be just sufficient for crops which have low water requirements, e.g., moth (*P. aconitifolius*) and ephemeral grasses.

(v) Rainfall less than 5 cm pm for three consecutive months is not of much significance for crop production.

2.4 For denoting the year's rainfall distribution using monthly totals, a convenient code in letter symbols with numerical subscripts explained below, has been evolved. The letters A to E in Table 1 indicate the ranges of monthly rainfall and the subscripts to these refer to the number of months having these ranges of rainfall e.g. A_2 indicates two months with rainfall greater than 30 cm pm. The ranges correspond to those stated in the preceding paragraph.

TABLE 1

Code for Rainfall Data

Symbol	Monthly rainfall cm pm
A+	Greater than 30
B	20—30
C	10—20
D *	5—10
E*	Less than 5

+An examination of monthly rainfall in the country shows that except for areas in the west coast and some hill station in extreme north-east, normal monthly rainfall seldom exceeds 40 cm.

*In distributions containing ranges of rainfall covered by A or B termed briefly as A&B types amounts less than 10 cm are not so significant and their frequency is generally small. To reduce the number of combinations, D is omitted in A or B type distributions; instead E is used to denote less than 10 cm pm. Thus $B_2 E_2$ would denote two months of 20—30 cm pm and two months less than 10 cm pm rainfall.

The southwest monsoon months of June to September being the principal rainy season dominate the rainfall distributions of the country. To indicate the season's importance, monthly rainfall distribution during June to September is shown in brackets in the annual pattern. To the right of the bracket is the distribution for the post-monsoon months, namely, October to January and to the left that for the pre-monsoon months namely, February to May. In order to explain how such a coded rainfall distribution written in symbols with numerical subscripts has to be interpreted, a hypothetical example may be considered. $D_1 E_3 (A_2 B_1 C_1) C_1 D_3$, in which for each of the three periods, the symbols are in order of decreasing rainfall which is not necessarily the calendar sequence, can be explained as under :

(i) $D_1 E_3$ represents the period February to May in which one month's rainfall (usually May) is in the range of 5-10 cm and the remaining three months get less than 5cm pm.

(ii) $A_2 B_1 C_1$ represents the period June to September, in which two months (usually July and August) get more than 30 cm pm rainfall, one month (September) gets 20-30 cm and the remaining month, i.e. June gets 10-20 cm.

(iii) $C_1 D_3$ represents the period October to January in which October gets 10-20 cm rainfall and the rest 5-10 cm pm.

Boundaries of Rainfall Zones

2.5 Since differences in monthly, seasonal and annual rainfall are not large within short distances, linear interpolation of rainfall data is permissible. Rainfall data being point measurements, isolines for the same or nearly the same type of distribution of monthly rainfall can, therefore, be drawn. These isolines may not necessarily follow the boundaries of taluks which are taken to be unit of area in this study and

hence for delineation of boundaries the following procedure has been adopted :

(i) Where variations are small, isolines follow the taluk boundaries;

(ii) where variations are large, isolines delineate the zone boundaries; and

(iii) any taluk, more than three quarters of which lies outside of a zone is not considered a part of that zone.

2.6 If an identical distribution is observed over two or more adjacent taluks a pattern is said to have evolved and the area covered by it is distinguished as a zone and indicated suitabily by a Roman numeral. Rainfall patterns have been identified for the whole country using the methodology described above. The data used for the analysis are the monthly normals of rainfall (1901 to 1950)[1] and the patterns and zones are depicted on all-India map which forms part of Chapter 14 on Rainfall and Cropping Patterns of the Commission's Report.

Cropping Patterns

2.7 The basic data for the study of cropping patterns of the country are the areas under different crops in each of the taluks. A large number of crops are grown in a taluk but most of them occupy small areas, often less than one per cent of the total cropped areas of the taluk. With a view to limiting the number of crops constituting a pattern only those crops are considered which individually occupy 10 per cent or more of the gross cropped area of the taluk. In this process, several crops have to be excluded, even though they may be otherwise important. The minimum limit has been fixed at 70 per cent, so that the number of crops, which together cover at least 70 per cent of the gross cropped area, and in which none occupies less than 10 per cent, is not large. Trial computations have shown that in such distributions any crop occupying more than 10 per cent area is rarely omitted and the number of crops hardly exceeds five. When the same distribution holds good for two or more adjacent taluks, a pattern is obtained.

2.8 As in the case of rainfall, percentage area coverage by crops is expressed by means of numerical subscripts affixed to crop symbols shown in Table 2. The list of crops given below is comprehensive and will hold good for all the States.

TABLE 2
Crop Symbols and Area Intervals

Crop	Symbol
1. rice	Pd
2. wheat	W
3. jowar (kharif)	Jk
4. jowar (rabi)	Jr
5. bajra	B
6. maize	M
7. ragi	R
8. small millets	Mt
9. barley	Ba

TABLE 2 (Contd.)

Crop	Symbol
10. oats	Oa
11. gram	G
12. pigeonpea (tur)	T
13. pulses other than pigeonpea and gram	Pu
14. groundnut	Gn
15. oilseeds other than groundnut	O
16. cotton	C
17. jute	Ju
18. other fibres	Fb
19. sugarcane	S
20. potato	Pt
21. vegetables	V
22. fruits	Fr
23. tapioca	Ta
24. plantations	L
25. fodder	F
26. chillies	Ch
27. tobacco	To

Area interval (per cent)	Subscript
70 or more	1
50—70	2
30—50	3
10—30	4
less than 10.	5

The crop code contains the crop symbol and the appropriate subscript. In writing crop distribution, the first crop has always the highest area but the rest may not necessarily follow the order of decreasing areas. For example, crop distribution, C_3 Jr_4 Mt_4, means that cotton area is 30-50 per cent and jowar rabi and millets each occupies 10-30 per cent of the gross cropped area, the total being 70 per cent or more. Two or more taluks having the same distribution of crops constitute a pattern. Cropping patterns so derived have been indicated on maps of 1 : 1 million size.

Relative Yield Index of Crops

2.9 Besides the absolute figures, the yield of a crop has also been expressed as per cent of all-India average which is called Relative Yield Index (RYI). Relative Yield Index values have been computed for the principal crops on the basis of (1968-69 to 1970-71) data available in the records of the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation.

Livestock Patterns

2.10 The livestock patterns are relevant only insofar as these are related to production of fodder and feeds. As talukwise data were not available for the livestock Census, 1972, those of 1966 Census as published by the States have been used. The animals considered for livestock analysis are shown in Table 3 together with their symbols.

Table 3

Livestock Symbols

Category	Symbol
cattle :	
male	
(over 3 years)	Cm
female	
(over 3 years)	Cf
young stock	
(under 3 years)	Cy
buffaloes :	
male	
(over 3 years)	Bm
female	Bf
(over 3 years)	
young stock	
(under 3 years)	By
sheep	S
goats	G
horses, mules and ponies	H
donkeys	D
camels	Ca
pigs	P

The livestock patterns are expressed in coded form in the same manner as the cropping patterns.

Soils

2.11 Soil data on a taluk basis are not available for all the areas of the country. As such, soils have been discussed in a general manner using the traditional nomenclature in describing their characteristics.

Other Data

2.12 The sources of other data featuring in the study are given below :

item	source
taluk area	States' Census Reports 1971 or from the data furnished by the States in their land-use returns.
orography	maps of the Survey of India and National Atlas Organisation.
temperature	Climatological Tables of Observatories in India, India Meteorological Department, 1931-1960 normals.
evapotranspiration	scientific Report No. 136 of the India Meteorological Department, 1971.
human population	Census of India, 1971.
irrigation and land use statistics	basic data pertaining to land utilisation statistics obtained from the States and refer mostly to 1969-70.

Presentation of Information

2.13 The tables required for following the text are given in the text itself at appropriate places, whereas the basic data are appended as follows :

APPENDIX 1	Districtwise Livestock Population—1966.
APPENDIX 2	Zonewise Information on Rainfall, Rainy days and Cropping Patterns
APPENDIX 3	Zonewise area under Principal Crops (per cent of Gross Cropped Area).

2.14 Rainfall, cropping and livestock patterns of each State are indicated on maps in the 1 : 1 million scale and given in Appendices 4, 5 and 6 respectively. In the case of rainfall patterns, the zonal numbers in State maps have been given in Roman numerals and their all-India equivalents as used in Chapter 14 of the Commission's Report have been shown in three digit Arabic numerals within brackets.

3 GENERAL FEATURES

3.1 The total geographical area of the State is 173,876 sq km. During 1969-71, there were 17 districts—6 in the plateau and 11 in the plains. The plateau occupies 46 per cent of the total geographical area. Excepting for Dhanbad (3,000 sq km) all the other districts of the plateau exceed 10,000 sq km in area, the highest being Ranchi and Hazaribagh (18,000 sq km).

3.2 The districts in the plains are much smaller in size. Area of five districts is between 4,000 and 8,000 sq km. Only three district, viz, Purnea, Gaya and Shahabad, have areas between 11,000 and 12,000 sq km. The distribution of areas of districts is given in Table 4 :

TABLE 4

Areawise Distribution of Districts

plateau					
area ('000 sq km)	3·0	12-14	14-16	16-18	18-20
number of districts	1	2	1	0	2
plain					
area ('000 sq km)	4-6	6-8	8-10	10-12	12-14
number of districts	3	2	3	2	1

3.3 The State has 58 sub-divisions. Their areas vary from less than 1,000 sq km to over 8,000 sq km. Two sub-divisions are less than 1,000 sq km and 45 are about equally divided in the area classes 1-2, 2-3 and 3-4 thousand sq km. Six sub-divisions in the plateau districts of Ranchi, Singhbhum and Hazari-bagh have areas of over 5,000 sq km each.

Elevation

3.4 In plains the general minimum elevation is 40 to 70 masl (metres above sea level) excepting south-ern parts of Gaya, Southwest Shahabad and southern sub-division of Monghyr, where it varies between 250 and 450 masl. The maximum elevations are less than 80 masl excepting southern or southwestern parts of Bhagalpur, Monghyr, Shahabad and Gaya, where they vary from 225 to 675 masl and in Bettiah of Cham-paran districts (880 masl).

3.5 In plateau areas, the minimum elevation in Late-har (Palamau), Hazaribagh, Dhanbad and Santhal Parganas is generally between 300 and 450 and in Ranchi and Singbhum between 450 and 650 masl. In northern parts of Palamau and Godda of Santhal Parganas, the minimum elevation is 140 to 150 masl only. The maximum elevation varies between 500 and 1,100 masl. In Hazaribagh sub-division, ele-vation is about 1,000 masl and in Ranchi, Gumla and Latehar 1,100 masl. The plains are generally less than 70-80 masl in height.

Population

3.6 The total population of the State according to 1971 Census is 56.4 million. The population density which was 223 per sq km in 1951 and 267 in 1961 rose to 324 in 1971. The 1971 density is 80 per cent higher than all-India figure (182). In plateau area, the average population density is 179. But for Dhan-bad (490), the population density would have been much less. Density in Palamau is only 119. The density in the plains on the other hand, is 447. There are 4 districts, Patna, Saran, Muzaffarpur and Dhar-banga each with more than a density of 600. The population density in various districts is given in Table 5 :

TABLE 5

Districtwise Density of Population

District	Area (sq km)	Population	Density per sq km
Patna	5,528	3,556,945	643
Gaya .	12,344	4,457,473	361
Shahabad	11,320	3,939,034	348
Saran	6,952	4,279,253	616
Champaran	9,196	3,543,103	385
Muzaffarpur	7,838	4,840,681	618
Darbhanga	8,679	5,233,904	603

2—736 Agrl/76

TABLE 5 *(Contd.)*

District	Area (sq km)	population	Density per sq km
Monghyr	9,827	3,892,609	396
Bhagalpur	5,656	2,091,103	370
Saharsa	5,885	2,350,268	399
Purnea	11,013	3,941,863	358
Santhal Parganas	14,129	3,186,908	226
Palamau	12,677	1,504,350	119
Hazaribagh	18,060	3,020,214	167
Ranchi	18,331	2,611,445	142
Dhanbad	2,994	1,466,417	490
Singhbhum	13,447	2,437,799	181
State	173,876	56,353,369	324

Land Use

3.7 Forests occupy 17 and land not available for cul-tivation 15 per cent of the geographical area. Fallow lands account for 15 per cent. The net sown area is about 48 per cent of geographical area. In the north-ern plains, districts from Champaran to Purnea and Saran and Patna, have no forests. From Shahabad to Santhal Parganas and in Dhanbad about 10 to 15 per cent area is under forests. Forest area is 20 to 25 per cent in Ranchi and Singhbhum and 45 per cent in Hazaribagh and Palamau districts. Net sown area is 20 per cent in Hazaribagh and Palamau, 30 per cent in Dhanbad, 40 per cent in Ranchi and Singhbhum, 50 to 60 per cent from Gaya to Bhagalpur and Saharsa, 73 to 78 per cent in Champaran, Muzaffarpur, Dar-bhanga and Patna and 65 to 70 per cent in the rest of the State. Area sown more than once in the State is 32 per cent of net sown area giving a cropping inten-sity of 132 per cent. Cropping intensity in the plateau districts is about 110 per cent excepting Palamau (123 per cent). The cropping intensity is higher in the plains being 160 in Purnea, 150 to 160 in Champaran, Shah-abad and Patna and 130 to 140 per cent in the remaining districts.

Soils

3.8 The soils in the plains are mostly recent alluvial excepting a small belt running from Saran and south Champaran to Saharsa, where these are cal-careous alluvial. Along the southern boundary of Shahabad and Gaya, the soils are red and yellow whereas these are red sandy in Bhagalpur. The plateau and a major portion of Hazaribagh and Ranchi Parganas have red and yellow soils whereas soils in the extreme eastern parts of Ranchi, Hazari-bagh, Dhanbad and Santhal Parganas are red sandy. A major portion of Singhbhum has mixed red and black and, in the extreme south-east, red and yellow soils. The rest of the area has red sandy soils.

Irrigation

3.9 The net irrigated area in the State in 1969-70 was 2.3 million ha which accounts for 27 per cent of net sown area. Irrigation in the districts shows wide variation. In the plateau districts, except for Palamau, area irrigated is less than 10 per cent. In Gaya, Shahabad and Patna nearly 65-80 per cent of net sown area is irrigated. The area irrigated as per cent of net sown and gross cropped areas in selected districts is given in Table 6. Nearly 36 per cent of area irrigated is by canals followed by tubewells (13 per cent) and tanks (8 per cent). 70 per cent of the irrigation in Shahabad is by canals. Champaran, Monghyr, Ranchi and Singhbhum have 45 per cent area irrigated by canals. 75 per cent of the area irrigated in Santhal Parganas is by tanks. As far as well irrigation is concerned, Patna has 30 per cent and Darbhanga and Palamau 25 per cent area irrigated by tubewells.

TABLE 6

Irrigated Areas as per cent of Net and Gross Sown Area

District	Net area irrigated as per cent of net sown area	Gross area irrigated as per cent of gross sown area
Gaya	80	65
Patna, Shahabad	65	50—6
Bhagalpur	50	40
Monghyr, Champaran, Saran and Palamau	25—30	20—25
Saharasa	13	same
rest	less than 10	
State	27	25

Rainfall

3.10 The normal monthly and annual rainfall along with CV are shown in Table 7. Plateau area is more rainy than the plains, the difference in annual rainfall and rainy days being 17 cm and 17 respectively. July and August have practically the same averages, CV in August is less than that of July for plateau but practically the same for the plains. The annual CV for plateau is only 11 per cent showing the small order of variability when the whole sub-division is considered.

3.11 January-February rainfall is generally less than 5 per cent of annual rainfall. During March to May, rainfall is less than 5 per cent in the western districts of Patna, Gaya, Shahabad, Saran, Palamau and western part of Hazaribagh and 5 to 10 per cent in other areas. June to September are the months of heaviest rainfall accounting for 80 to

85 per cent of annual rainfall. October-December rainfall is 5 to 10 per cent of annual average.

3.12 The main features of monthly, seasonal and annual rainfall are considered below :

January—May

Rainfall during January is 1 to 2.5 cm in the plains and eastern half of the plateau and higher in the west. Rainfall in February is nearly similar. The seasonal total is 5 to 7.5 cm in the western part of the plateau and 2.5 to 5 cm elsewhere. March rainfall is less than 1 cm in the plains and 1 to 2.5 cm in other areas. April rainfall is higher and ranges from less than 1 cm to the west of Patna to 5 cm in the extreme northeast. During May, rainfall increases from less than 2.5 cm to the west of Patna to 15 to 20 cm in the extreme northeast The seasonal total is less than 5 cm in Patna, Gaya, Shahabad and southern half of Saran and rises rapidly in the north, east and south to 15 cm in the east and to more than 30 cm in the extreme northeast.

June—September

July rainfall in most of the southern half of the plains is less than 30 cm and it rises to 40-50 cm south of Ranchi and in the northeast. August rainfall is similar with reduced areas of less than 30 cm to a small belt to the north of Patna and higher than 40 cm in the south-west and northeast. Rainfall diminishes significantly in September to 20-30 cm. The seasonal total rainfall is 75 to 100 cm in the southern half of the plains and 100 to 150 cm in the rest of the State.

October—December

October rainfall is 5 to 10 cm excepting a small area near Patna, which gets less than 5 cm. November rainfall is less than 1 cm in the northern half of the plains and 1 to 2.5 cm elsewhere. Rainfall in December is negligible. The seasonal total rainfall is mostly between 5 to 10 cm.

Annual

The annual total rainfall is 100 to 150 cm except for a pocket near Patna, which gets slightly less than 100 cm and in the extreme southwest and northeast, where the amounts exceeds 150 cm.

Rainfall Variability

3.13 The coefficient of variation (CV) during January-February is 100 per cent or higher, and the seasonal CV is about 80 to 100 per cent. During March to May, CV is more than 100 per cent

but, in a small area in the northeast, May CV is only 40 to 60 60 per cent. Seasonal CV is 80 to 100 per cent in the south western part of the plains and 40 to 80 per cent elsewhere. The rainfall in northeastern area is less variable with 40 to 60 per cent CV. June CV is 60 to 80 per cent except in the northeast, where it is 50 to 60 per cent. CV is less than 40 per cent in the plateau and 40 to 50 per cent in the plains. August CV is somewhat similar, but in the plateau there is a pocket of less than 30 per cent. September CV is higher—40 to 50 per cent in the plateau and above 50 in the plains. Seasonal CV is less than 20 per cent in the southern half of the plateau and 20 to 30 per cent elsewhere. October CV is 100 per cent in southern half of plateau and higher elsewhere. November and December CV exceed 100 per cent. Seasonal CV is 80 to 100 per cent in the plateau and higher in the plains. Annual CV is 20 to 25 per cent in the plains and less than 20 per cent in the plateau.

Temperature

3.14 Normals of daily maximum and minimum and mean daily temperatures for 16 observatory stations in the State are given in Tables 8 to 10. Some of the main features are briefly considered below :

(i) December and January are the coldest months of the year. January mean minimum is 9° to 10°C except from Shahabad to Santhal Parganas, and in Dhanbad and Singhbhum areas where they are 11 to 12°C. In the northern and eastern areas January is colder than December by half to one degree and elsewhere December is colder by a few tenths of a degree, the difference being negligible. In the rainiest months of July and August temperatures show little or no difference. On the mean, Ranchi and Hazaribagh have mean minimum temperatures of 22-23°C and elsewhere these are 25 to 26°C.

(ii) April and May are the hottest months of the year. Mean maximum in April ranges between 36° to 39°C, the highest value of 39°C is from Shahabad to Monghyr and in Singhbhum. The lowest values are about 36°C in Hazaribagh and Ranchi and in the northern districts from Champaran to Purnea. May temperature is invariably higher than April by 1° to 3°C in the west. In Purnea, May temperature is less than April by a degree and in Naya Dumka the two are the same. With the setting in of rains during June.

temperatures are reduced and in July mean maximum is between 29 to 34°C. Hazaribagh and Ranchi have averages of 29 to 29.5°C. Mean is 33°C in Palamau and from Shahabad to Patna and Monghyr. Elsewhere, it is 31 to 33°C. July to September mean maximum temperatures show little variation (0.3 to 0.5°C) except in Palamau to Patna and west of it where the differences are of the order of a degree. This important feature of every little variation in the rainy months of July to September may be noted. The mean annual temperature maximum is 29.5°C in Hazaribagh and Ranchi, 32°C from Palamau, Shahabad to Monghyr and Santhal Parganas and in Singhbhum and 31°C elsewhere. The annual mean temperature is 23-24°C in Hazaribagh and Ranchi, 26-27°C from Palamau, Shahabad to Santhal Parganas, Dhanbad and Singhbhum areas and 25°C elsewhere.

Potential Evapo-Transpiration (PE)

3.15 Monthly and annual values of potential evapotranspiration (PE) worked out from Penman's formula for 16 observatory stations in the state are given in the Table 11. Brief remarks follow on their distribution. Potential evapo-transpiration in December and January is generally 5-6 cm. Rainfall is less than half the PE of these months. PE rapidly rises and is maximum in May. June PE is 15-16 cm except in Gaya and Shahabad which have higher values of 18 to 20 cm. This is much higher than the rainfall of the month over most of the State. July and August are the rainiest months and PE is 10 to 12 cm, except in Patna and Gaya, which have 2 to 3 cm higher. PE in these months is generally half to one-third of the rainfall of these months. Ranchi and areas south of Ranchi have lower PE values. September PE is similar with 10-11 cm except for 14 cm in Gaya. Rainfall of this month is generally higher than PE. The annual PE is 130 in Ranchi and to its south. 130 to 140 cm in the northern districts from Champaran to Purnea and in Palamau and Hazaribagh. PE's in the central districts are distinctly higher (145—155 cm) except in Gaya, which has a value of about 166 cm.

Climatic Classification

3.16 The State is divided into three major climatic regions. In terms of classification, Gaya and south Monghyr are semi-arid, eastern parts of Purnea, Santhal Parganas and south of Ranchi are moist sub-humid and the remaining areas are dry sub-humid. Thus, except for the area in Gaya and neighbourhood, climate is dry to moist sub-humid.

TABLE 7

Normal Monthly and Annual Rainfall and Coefficient of Variation

Plateau	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
r	2·1	3·1	2·0	1·9	5·1	19·6	35·8	34·4	21·8	8·3	1·6	0·5	137·2
n	1·6	2·4	1·7	1·7	3·5	9·9	17·0	16·9	10·9	4·3	0·9	0·4	71·2
CV	112	92	108	83	60	46	25	18	29	83	168	203	11
per cent of annual rainfall	1·5	2·3	1·5	1·4	3·7	14·3	26·1	25·8	15·9	6·0	1·2	0·4	
Plains													
r	1·4	2·0	1·1	1·6	4·8	17·2	31·1	31·4	22·5	5·9	0·9	0·4	120·3
n	1·2	1·6	0·9	1·2	2·7	7·5	13·1	13·4	9·1	2·5	0·5	0·3	54·0
CV	106	90	120	103	55	49	27	26	35	91	196	241	14
per cent of annual rainfall	1·2	1·7	0·9	1·3	4·0	14·3	25·9	26·1	18·7	4·9	0·7	0·3	

r—rainfall in Cm   n—number of rainy days
CV—Coefficient of Variation (%) of rainfall (R)

TABLE 8

Normals of Daily Maximum Temperature (°C)

Station	Jan	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Bihar plateau													
Dumka	25·3	28·0	34·0	38·0	37·9	35·1	31·8	31·6	31·9	31·5	28·7	25·9	31·6
Daltonganj	24·4	27·0	33·0	38·3	41·6	38·3	32·5	31·5	30·9	31·2	28·1	25·1	31·8
Hazaribagh	22·8	25·1	30·9	35·8	38·0	34·6	29·5	29·2	29·5	28·6	25·6	28·1	29·5
Dhanbad	24·7	27·4	33·2	37·6	38·8	35·9	31·2	30·8	31·2	30·6	27·8	25·2	31·2
Ranchi	23·6	25·9	31·2	35·9	37·9	34·2	29·1	28·9	29·2	38·5	25·7	23·7	29·5
Jamshedpur	26·7	29·2	34·6	38·7	40·0	36·5	32.0	31·8	32·1	36.1	29·1	26·8	32·4
Chaibasa	26·5	29·2	34·7	38·9	40·5	36·7	31·7	31·4	31·7	31·0	28·5	26·6	32·3
Bihar plains													
Motihari	22·9	25·4	31·5	36·0	36·7	34·6	32·5	32·2	32·0	31·3	28·0	24·2	30·6
Darbhanga	23·6	25·9	31·7	35·9	36·4	34·5	32·4	32·1	32·2	31·4	28·7	25·2	30·8
Purnea	24·3	26·6	32·2	36·0	35·1	33·2	32·0	32·9	32·2	31·5	28·8	25·5	30·8
Patna	23·6	26·3	32·9	37·6	38·9	36·7	32·9	32·1	32·3	31·9	28·9	24·9	31·6
Bhagalpur	24·0	27·4	33·0	37·9	38·3	35·3	32·5	32·3	32·5	32·0	29·0	25·5	31·6
Sabour	23·6	26·4	32·8	36·9	37·4	34·9	32·3	31·9	32·1	31·2	28·3	24·8	31·1
Jamui	24·4	28·3	33·9	39·2	40·2	37·2	32·6	32·3	31·9	31·4	29·1	25·9	32·2
Dehri	23·8	27·7	33·5	39·3	42·0	38·9	33·0	32·3	32·0	31·8	28·9	25·6	32·4
Gaya	24·5	27·0	33·7	39·0	41·3	38·6	33·5	32·4	32·6	31·2	28·5	25·1	32·3

TABLE 9

Normals of Daily Minimum Temperature (°C)

Station	Jan	Feb	Mar	Apr	May	June	July	August	Sept	Oct	Nov	Dec	Annual
Dhar plateau													
Biumka	10·6	13·2	18·4	22·7	25·5	26·0	25·3	25·1	24·7	21·6	15·1	11·4	20.0
Daltonganj	9·4	11·7	16·1	21·2	25·4	27·6	25·5	25·1	24·4	20·2	12·8	8·8	19.0
Hazaribagh	9·6	12·0	16·7	21·4	24·4	24·7	23·2	23·0	22·4	18·7	12·7	9·4	18·2
Dhanbad	12·1	14·5	19·2	23·5	25·9	25·9	24·8	24·8	24·3	21·7	15·6	12·4	20·4
Ranchi	9·9	12·2	16·7	21·1	24·0	23·9	22·6	22·4	21·9	18·5	13·0	9·9	18·0
Jamshedpur	11·8	14·3	18·7	23·7	26·8	27·0	25·9	25·7	25·4	22·2	15·5	11·6	20·7
Chaibasa	12·0	14·4	19·3	24·1	26·8	26·7	25·3	25·0	24·7	21·6	15·4	11·7	20·6
Bihar plains													
Motihari	8·9	10·2	15·0	19·9	24·2	25·7	25·3	26·0	25·2	21·1	13·8	9·7	18·8
Darbhanga	10·0	11·6	16·3	21·3	24·7	26·0	26·2	26·2	25·8	22·3	15·2	10·8	19·7
Purnea	8·8	11·1	15·5	20·5	23·9	25·4	25·9	25·9	25·3	21·5	14·4	9·8	19·0
Patna	11·0	13·4	18·6	23·3	26·0	27·1	26·7	26·6	26·3	23·0	16·1	11·7	20·8
Bhagalpur	11·8	14·3	19·1	23·6	25·7	26·4	26·2	26·9	25·9	23·1	16·6	12·8	21·0
Sabour	8·4	10·7	15·7	21·2	24·9	26·3	26·3	26·3	25·8	21·9	14·0	9·1	19·2
Jamui	10·9	13·3	18·9	23·7	26·6	27·3	26·3	26·0	25·5	22·1	14·9	11·4	20·6
Dehri	11·6	14·2	19·1	24·2	28·0	28·1	26·4	26·1	25·5	22·0	15·0	11·9	21·0
Gaya	10·1	12·2	17·4	23·0	27·4	28·2	26·3	25·9	25·6	21·7	14·1	9·9	20·2

TABLE 10

Normals of Daily Mean Temperature (°C)

Station	Jan.	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Bihar plateau													
Dumka	18·0	20·6	26·2	30·4	31·7	30·6	28·6	28·4	28·3	26·6	21·9	18·7	25·9
Daltonganj	16·9	19·4	24·6	29·8	33·5	33·0	29·0	28·3	27·7	25·7	20·5	17·0	25·5
Hazaribagh	16·2	18·6	23·8	28·6	31·2	29·7	26·4	26·1	26·0	23·6	19·2	16·3	23·8
Dhanbad	18·4	21·0	26·2	30·6	32·4	30·9	28·0	27·8	27·8	26·2	28·7	18·8	25·8
Ranchi	16·8	19·1	24·0	28·5	31·0	29·1	25·9	25·7	25·6	23·5	19·4	16·8	23·4
Jamshedpur	19·3	21·8	26·7	31·2	33·4	31·8	29·0	28·8	28·8	26·9	22·3	19·2	26·6
Chaibasa.	19·3	21·8	27·0	31·5	28·5	31·7	28·5	28·2	28·2	26·3	22·0	19·2	26·5
Bihar plains													
Motihari	15·9	17·8	23·3	28·0	30·5	30·2	28·9	29·1	28·6	26·2	20·9	17·0	24·7
Darbhanga	16·8	18·8	24·0	28·6	30·6	30·3	29·3	29·2	29·0	26·9	22·0	18·0	25·3
Purnea	16·6	18·9	23·9	28·3	29·5	29·3	29·0	28·9	28·8	26·5	21·6	17·7	24·9
Patna	17·3	19·9	25·8	30·5	32·5	31·9	29·8	29·4	29·3	27·5	22·5	18·3	26·2
Bhagalpur	17·9	20·9	26·1	30·8	32·0	30·9	29·4	29·3	29·2	27·6	22·8	19·2	26·4
Sabour	16·0	18·6	24·3	29·1	31·2	30·6	29·3	29·1	29·0	26·6	21·2	17·0	25·2
Jamui	17·7	20·8	26·4	31·5	33·4	32·3	29·5	29·2	28·7	26·8	22·0	18·7	26·4
Dehri	17·7	21·0	26·3	31·8	35·0	33·5	29·7	29·2	28·8	26·9	22·0	18·8	26·8
Gaya	17·2	19·6	25·6	31·0	34·4	33·4	29·9	29·2	29·1	26·3	21·3	17·5	26·3

TABLE 11

Normal Monthly and Annual Potential Evapotranspiration (mm)

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Bihar plateau													
Nayadumka	65·6	86·5	139·6	175·4	193·8	153·1	127·4	122·8	117·3	114·5	79·9	61·4	1437·9
Daltonganj	67·4	82·6	132·5	167·6	199·2	162·9	118·3	103·2	106·3	111·1	75·4	56·3	1388·3
Hazaribagh	70·2	90·8	144·4	176·1	193·8	142·2	104·0	102·3	96·3	105·1	77·7	63·0	1366·5
Dhanbad	80·9	103·6	164·1	197·2	198·0	168·5	125·0	115·5	110·9	114·2	93·7	76·7	1548·8
Ranchi .	66·5	86·3	135·3	165·0	184·6	134·9	99·3	95·8	97·9	101·9	75·1	60·8	1304·0
Jamshedpur	72·8	94·2	144·9	179·0	200·8	151·9	114·1	107·9	107·9	111·7	85·1	67·1	1438·0
Chaibasa.	69·5	88·5	137·0	162·4	176·5	128·7	100·8	95·7	94·1	103·1	80·8	64·8	1302·2
Bihar plains													
Motihari	48·6	67·9	124·1	166·1	196·3	153·4	122·7	115·0	111·4	111·4	69·1	46·0	1332·6
Darbhanga	52·0	71·1	126·1	170·2	205·6	152·3	123·9	116·8	108·6	112·6	73·1	50·0	1362·9
Purnea	55·2	76·6	131·7	167·6	178·7	133·5	117·2	113·2	108·8	111·5	73·6	51·8	1320·1
Patna	63·5	87·0	147·5	118·9	218·6	166·4	139·5	114·6	114·2	122·0	81·3	60·1	1504·3
Bhagalpur	65·1	92·3	150·6	201·9	212·9	147·1	114·9	111·1	109·2	115·9	83·0	62·4	1467·0
Sabour	55·9	78·6	142·1	186·4	199·9	142·6	114·8	108·2	105·7	111·6	74·8	53·0	1374·0
Jamui	62·6	90·2	145·8	192·3	218·5	164·0	115·9	109·4	109·2	112·4	78·2	59·4	1458·5
Dehri	65·5	94·1	149·7	189·5	217·1	180·7	119·9	111·0	111·1	118·4	81·0	62·1	1500·7
Gaya	70·5	94·8	162·1	209·1	250·3	202·4	140·5	122·9	135·6	122·3	85·5	64·8	1661·4

4 RAINFALL ZONES TOGETHER WITH THEIR CROPPING AND LIVESTOCK PATTERNS

4.1 The State is divided into 17 rainfall zones. These are given below together with the sub-divisions and their approximate area.

Rainfall Zone	Rainfall pattern	Number sub-divisions	Area (sq km)
I	$E_4(B_2C_2)E_4$	2	3504
II	$E_4(B_2C_2)D_1E_3$	1	2665
III	$E_4(A_1B_1C_2)E_4$	1	2629
IV	$E_4(A_1B_1C_2)D_1E_3$	1	2012
V	$E_4(A_1B_2C_1)E_4$	1	1420
VI	$E_4(A_1B_2C_1)D_1E_3$	9	15152
VII	$E_4(A_2B_1C_1)E_4$	1	4950
VIII	$E_4(A_2B_1C_1)D_1E_3$	13	46147
IX	$E_4(A_2B_2)D_1E_3$	2	8854
X	$D_1E_3(B_2C_2)D_1E_3$	3	7672
XI	$D_1E_3(A_1B_1C_2)D_1E_3$	1	2431
XII	$D_1E_3(A_1B_2C_1)D_1E_3$	1	3475
XIII	$D_1E_3(A_2B_1C_1)D_1E_3$	5	14903
XIV	$D_1E_3(A_2B_2)D_1E_3$	14	50133
XV	$C_1E_3(A_2B_2)C_1E_3$	1	1782
XVI	$C_1E_3(A_3B_1)D_1E_3$	1	2666
XVII	$C_1E_3(A_4)D_1E_3$	1	1934

4.2 An introductory description of the rainfall zones is provided below before taking up their consideration in detail individually.

(a) The zoning of the State has been examined using rainfall data for the various sub-divisional stations. The months of February to April get less than 5 cm pm throughout the State. In May, however, about half the sub-divisions get more than 5 cm and three more than 10 cm.

(b) November to January are months of low rainfall and receive less than 5 cm pm in the entire State. October has more rains and the amounts are more than 5 cm excepting five sub-divisions, viz., Patna (2) Gaya (3) Naya Dumka gets more than 10 cm.

(c) July and August are the months receiving highest rainfall and there is no sub-division with less than 20 cm pm in these months, coded as (B_2). B_2 C_2 is the lowest distribution and covers half a dozen sub-divisions, two each in Patna and Bhagalpur and one each in Santhal Parganas and Saran districts. The highest A_4 is in extreme northwest sub-

division of Kishanganj, A_3 B_1 in adjoining Araria and A_2 B_2 and A_2 B_1 C_1 include 60 per cent of the sub-divisions.

(d) The patterns of distribution for the three seasons combined would have been small, only seven listed in (c) above but for May and October, which receive more than 5 cm over large parts of the State. Combining (a) and (c) the State has 17 patterns and hence the State is divided into 17 rainfall zones. Ten of these cover one sub-division each have been ratained as their area are large. Two patterns, D_1 E_3 $(A_2 B_2)$ D_1E_3 and $E_4(A_2B_1C_1)$ D_1E_3, include 13-14 sub-divisions each and together account for nearly half the sub-divisions of the State. In area too, they are 46-48 thousand sq km each and together account for 55 per cent of the area of the State. The distribution of zonal areas as follows :

area ('000 sq km)	Nnumber of zones
1—2	3
2—5	10
15	2
46	1
48	1

Rainfall Zone I—$E_4(B_2C_2)E_4$

4.3 The districts, sub-divisions and the cropping pattern of the zone are :

Cropping Pattern	Sub-division	District
$Pd_3 W_4$	Bihar	Patna
$Pu_3Pd_4W_4$	Barh	,,

4.4 The annual rainfall is 100 cm. August receives a rainfall of 30 cm followed by July (24-28 cm), June (14 cm) and September (19 cm).

4.5 Area under paddy is nearly 50 per cent in Bihar sub-division and 25 per cent in Barh. Wheat area is 10 to 15 per cent and that of pulses 24 to 33 per cent of the total.

4.6 The average yield of rice in Patna district is 90 per cent of all-India average yield. For an irrigated crop, the yield is low. The Relative Yield Index of wheat is 84 per cent and it is low.

4.7 Male cattle and goats have about the same percentage. There are 10-12 per cent of female and young stock of buffaloes in Patna district. The district pattern is : $Cm_4 G_4 Cf_4 Cy_4/Bf_4$.

Rainfall Zone II—E$_4$(B$_2$C$_2$)D$_1$E$_3$

4.8 Only Chapara sub-division of Saran district constitutes the zone, which has an area of 2665 sq km.

4.9 July and August receive 28-30 cm pm. rainfall and September gets 20 cm. Average rainfall in June is 14 cm and in October 5 cm.

4.10 Rice and maize each occupy above 25 per cent of cropped aaca. Wheat is 16 per cent and barley 7 per cent. The pattern for the sub-division is : Pd$_4$ M$_4$ W$_4$ Ba$_4$.

4.11 Yield of rice in Saran district is 60 per cent of all-India average yield. Irrigation is negligible and the crop is rainfed. Maize yield is 120 per cent and 33 per cent more than the State average. Only 5 per cent of the crop area is irrigated. Rainfall distribution is adequate and the yield is satisfactory. Though wheat is irrigated to an extent of 60 per cent, yield in the district is only 70 per cent of all-India. which is low.

4.12 Of all the livestock, goats dominate in Saran district followed by male cattle. The pattern is: G$_3$ Cm$_4$ Cf$_4$/Cy$_4$.

Rainfall Zone III— E$_4$(A$_1$B$_1$C$_2$)E$_4$

4.13 Nawada sub-division of Gaya district constitutes the zone, with an area of 2629 sq km.

4.14 The annual average rainfall is about 100 cm in 57 rainy days. July and August are the rainiest months with a rainfall of 27 and 31 cm respectively. June has a rainfall of 12 and September 18 cm.

4.15 Paddy covers about 50 per cent of cropped area followed by pulses (29 per cent) and wheat (11 per cent). The pattern is : Pd$_2$ Pu$_4$.

4.16 Rice yield in Gaya district is 72 per cent of all-India average yield. The crop is entirely irrigated but the yield is low. Wheat yield is 64 per cent though half the area is irrigated.

4.17 Male cattle are in larger number in the district followed by goats. The pattern is : Cm$_4$ G$_4$ Cf$_4$/Cy$_4$.

Rainfall Zone IV—E$_4$(A$_1$B$_1$C$_2$)D$_1$E$_3$

4.18 Hajipur sub-division of Mazaffarpur district constitutes the zone, which has an area of 2,012 sq km.

4.19 Rainfall of the sub-division is about 110 cm. August is the rainiest month with 31 cm followed by July (27 cm.), June (15 cm), September (20 cm) and October getting slightly higher rainfall than zone III. The distribution is practically the same as for Zone III.

4.20 Paddy occupies about 30 per cent of the cropped area and maize 21 per cent. Wheat and other pulses each are about 10 per cent in area. The pattern is : Pd$_4$ M$_4$ W$_4$ Pu$_4$.

4.21 Rice yield of Muzaffarpur district is 61 per cent of all-India average yield. This may be due to inadequate rainfall and also to lack of irrigation.

4.22 Goats account for 36 per cent of livestock in Muzaffarpur district and the pattern is : G$_3$ Cm$_4$ Cf$_4$/Cy$_4$.

Rainfall Zone V—E$_4$(A$_1$B$_2$C$_1$)E$_4$

4.23 This zone comprises only one sub-division, viz., Jehanabad of Gaya district. which has an area of 1,420 sq km.

4.24 The annual rainfall in the zone is about 110 cm in 55 rainy days. August is the rainiest month (33 cm) followed by July (30 cm). August (21 cm) and June (13 cm.).

4.25 The main crops of the sub-division are paddy (66 per cent), Wheat (8 per cent) and other pulses (13 per cent). The pattern is : Pd$_2$ Pu$_4$/W$_4$. This sub-division forms part of a big cropping zone extending over several sub-divisions.

4.26 In Gaya district yield of parry is 72 per cent of all-India average yield, though the crop is entirely irrigated. Wheat yield is 64 per cent of all-India yield though the crop is irrigated to an extent of 50 per cent, the yield is low.

4.27 The livestock pattern of Gaya district is : Cm$_1$ G$_4$ Cf$_4$ Cy$_4$.

Rainfall Zone VI—E$_4$(A$_1$B$_2$C$_1$)D$_1$E$_3$

4.28 The districts, sub-divisions and cropping patterns of the zone are :

Cropping pattern	Sub-division	district
Pd$_4$M$_4$W$_4$S$_4$Ba$_4$	Gopalganj	Saran
M$_3$ W$_4$ Pd$_4$	Begu Sarai Khagaria	Monghyr
Pd$_3$ Pu$_4$ W$_4$	Monghyr	..
Pd$_2$ Pu$_4$/W$_4$/M$_4$/Mt$_4$	Jamui	.,
Pd$_3$Pu$_4$/W$_4$/M$_4$/Ju$_4$	Buxar	Shahabad
Pd$_3$ Pu$_4$	Patna Sadar Patna City Dinapur	Patna

4.29 The zone covers entire Monghyr district and a good part of Patna besides one sub-division each of Saran and Shahabad districts. The total area of the zone is over 15,000 sq km (7-8 per cent of the geographical area of the State). Excepting for Patna sadar and patna city sub-divisions which are less than 1,000 sq km each, the areas of the other sub-divisions vary between 1,100 and 3,400 sq km, the largest area being of Jamui (3,400 sq km).

4.30 Excepting Jamui and Monghyr, the whole zone is plain. In Jamui the elevations range from 250 to 650 masl while the maximum elevation in Monghyr is 250 masl.

4.31 Forests and land not available for cultivation is about a third in area and fallow lands are 13 per cent. Net sown area is 52 per cent. In Patna 18 per cent land is not available for cultivation and the sown area is 76 per cent. Soils are mainly recent alluvial.

4.32 The annual rainfall is 120 cm and half of this is received during July (31 cm) and August (29 cm). June rainfall is only 18 cm and that of September 22 cm May gets nearly 5 cm and October 7 cm of rainfall.

4.33 There is some diversity in the cropping pattern in this zone. Excepting Khagaria and Begu Sarai where maize is 40 per cent, remain- 20 per cent and paddy 10 per cent, remaining 7 sub-divisions have paddy area as largest, varying from about 30 per cent in Gopalganj to 60 per cent in Jamui. In all, four patterns cover these seven sub-divisions. Patna and Dinapur sub-divisions have 45 per cent paddy and more than 25 per cent 'other pulses', the pattern being : $Pd_3 Pu_4$. Jamui with 62 per cent paddy has $Pd_2 Pu_4$ pattern. Monghyr comes under the pattern $Pd_3 Pu_4/W_4$ and Buxar under $Pd_3 Pu_4/W_4 M_4/Ju_4$. In Gopalganj, sugarcane area is about 10 per cent. It is included in the crop pattern of this sub-division with paddy, maize and wheat $Pd_4 M_4 W_4 S_4/Ba_4$. In all, the zone has five cropping patterns.

4.34 In Monghyr and Patna, rice yields are 70 and 90 per cent of all-India respectively. The rainfall distribution is not adequate for growing rice but the crop is grown under fully irrigated conditions in Patna and 60 per cent in Monghyr. The yield levels reached under these conditions are however low, particularly in the case of Monghyr where it is only equal to the State average and a quarter below all-India. The yield of wheat in Patna and Monghyr are rather low, 84 and 67 per cent of all-India respectively. The yield of maize is nearly the same as all-India. The rainfall distribution is however, satisfactory for a crop like maize. The yield of total pulses is well above all-India. In Patna it is close to 150 per cent and in Monghyr about 130 per cent of all-India.

4.35 Goats form a larger constituent of livestock population in Monghyr and Saran districts with pattern $G_3 Cm_3 Cf_4/Cy_4$. Shahabad has more male cattle than goats, which form the next highest category, the pattern being $Cm_4 G_4 Cf_4 Cy_4$.

Rainfall Zone VII—$E_4(A_2B_1C_1)E_4$

4.36 Gaya is the only sub-division included in this zone.

4.37 The area of the zone is 4,950 sq km. and the elevations range between 260 and 550 masl. The soils are recent alluvial.

4.38 The annual rainfall is 120 cm in 60 rainy days. July and August receive about 35 cm pm of rainfall,

which is nearly 60 per cent of annual. Rainfall in September is 20 cm and in June 14 cm.

4.39 Paddy covers more than half the area and wheat and pulses are about 13 to 15 per cent each. The pattern is : $Pd_2 W_4/Pu_4$.

4.40 Though the entire rice area in Gaya district is irrigated, its yield is low being only 72 per cent of all-India. Only 50 per cent area under wheat is irrigated and its yield is 64 per cent of all-India.

4.41 The pattern for Gaya district where male cattle are larger number than the rest is : $Cm_4 G_4 Cf_4 Cy_4$.

Rainfall Zone VIII—$E_4(A_2B_1C_1)D_1E_3$

4.42 The district, sub-divisions and the cropping patterns in the zone are :

Cropping Pattern	Sub-division	District
Pd4 M4 W4 Pu4/Ba4/S4	Siwan	Saran
Pd3W4Pu4	Arrah	Shahabad
Pd3 W4	Sasaram	,,
Pd2W4/Pu4]	Aurangabad	Gaya
Pd3 M4 Pu4 O4 .	Garhwa Daltonganj Latehar	Palamau ,, ,,
Pd2 W4/Pu4/M4/Mt4	Chatra Hazaribagh	Hazaribagh ,,
Pd2 W4/Pu4/M4/Mt4	Simdega	Ranchi
Pd1	Dhanbad Baghmara	Dhanbad ,,

4.43 The area of the zone is 46,147 sq km (27 per cent of the geographical area of the State). The average area of a sub-division in this zone is more than 3,000 sq km, the largest area being of Hazaribagh sub-division. (8,600 sq km) and the lowest that of Dhanbad.

4.44 Siwan and Arrahare plains with elevations of 60 to 90 masl. In the plateau area, elevations range from 300 to 1000 masl.

4.45 Net sown area is only 20 per cent in Palamau and Hazaribad and 30 per cent in Dhanbad. This is due to large areas under forest, land net available for cultivation and fallow lands. Ranchi has 40 per cent net sown area. In the rest of the zone, net sown area is as high as 60 to 70 per cent.

4.46 The soils are red sandy in Dhanbad and red and yellow in Hazaribagh, Palamau and Ranchi areas. In the rest of the zone, the soils are mostly recent alluvial.

4.47 The annual rainfall is 110 to 130 cm in the plains and 130 to 150 cm elsewhere. The month of maximum rainfall is generally August. July and August together contribute more than 50 per cent of

annual rainfall. Only July to September receive more than 20 cm rainfall. June rainfall is the lowest and October gets more than 5 cm.

4.48 Paddy is the major crop of the zone. It occupies 80 per cent of the area in Dhanbad, 55 to 60 per cent in Ranchi, Hazaribagh and Gaya, 35 per cent in Palamau, 45 per cent in Shahabad and about 30 per cent in Saran. The zone has eight cropping patterns-one each with Pd_1 and Pd_4 and three each with Pd_2 and Pd_3. The other crops in the patterns are one or more of wheat, other pulses, maize and other oilseeds. Oilseeds are significant in Palamau district.

4.49 Rice yield in Dhanbad is highest being 95 per cent of all-India, elsewhere it is 60 to 75 per cent. In spite of full or nearly full irrigation, yields in Gaya and Shahabad are low. Wheat is grown mainly in the districts of northern plains excepting palamau, a plateau district. Palamau yield is only 54 per cent though 33 per cent of area under wheat is under irrigation. Shahabad yield is 74 per cent with 75 per cent irrigation and Gaya with about 50 per cent irrigation has a yield of 64 per cent. Yield is 70 per cent only in Saran where 60 per cent of area is irrigated. As regards maize, Saran district has the best yield of 120 per cent of all-India and Shahabad has the lowest with 39 per cent. Except for Saran, the yields hardly reach 90 per cent. Pulses have low yields (70 to 90 per cent of all-India) in the plateau districts excepting Dhanbad (109 per cent). Yield in Shahabad is 120 per cent and Saran 130 per cent.

4.50 Among livestock, goats predominate in Ranchi, Dhanbad and Saran. The patterns are :

Ranchi
Saran $\Big\}$ G_3 Cm_4 Cf_4/Cy_4

Dhanbad
Hazaribagh $\Big\}$ G_4 Cm_4 Cf_4 Cy_4

The rest of the zone has Cm_4 C_4 Cf_4 Cy_4 pattern.

Rainfall Zone IX—$E_4(A_2B_2)D_1E_3$

4.51 The sub-Divisions in the zone and their cropping pattern is given below :

Cropping pattern	Sub-division	District
Pd_2 Pu_4	Gumla	Ranchi
	Khunti	,,

4.52 The area of the zone is 8,854 sq km and the elevations range between 450 and 1102 masl. Soils are mainly red and yellow. Red sandy soils are present in the southeastern part of Khunti.

4.53 The annual rainfall is 150 to 160 cm in 80 rainy days. July and August together contribute more than 50 per cent of total rainfall.

4.54 Paddy occupies more than 55 per cent of the area followed by other pulses (12 per cent). The pattern is : Pd_2 Pu_4 for both the sub-divisions.

4.55 In Ranchi, yield of rice is 66 per cent of all-India and is nearly the same as the State average. Rice crop was 22 per cent irrigated in 1969-70. The yield of small millets is the same as all-India. The yield of all pulses combined is 83 per cent which is lower than the State average of 109 per cent.

4.56 The livestock pattern in Ranchi district is : G_3 Cm_4 Cf_4 Cy_4.

Rainfall Zone X—$D_1E_3(B_2C_2)D_1E_3$

4.57 The sub-divisions and the cropping patterns in the zone are :

Cropping pattern	Sub-divisions	District
Pd_4 M_4 W_4 Pu_4	Bhagalpur	Bhagalpur
Pd_2 Pu_4	Banka	,,
Pd_2 Pu_4	Godda	Santhal Parganas

4.58 The areas of the sub-divisions vary from 2,300 to 3,000 sq km. In Bhagalpur and Banka, the elevations range between 50 and 400 masl. Godda is more elevated and minimum and maximum heights are 150 and 570 masl. Godda soils are red sandy and mainly recent alluvial elsewhere.

4.59 The annual rainfall is 110 to 120 cm in 60 rainy days. July is generally the month of maximum rainfall. The rainfall distribution in July and August is in B class. This is the lowest class in the State.

4.60 Godda and Banka have more than 60 per cent area under paddy and 10 per cent under pulses. Godda has 10 per cent of area under maize. The pattern for these two is : Pd_2 Pu_4. Bhagalpur has a number of crops with smaller areas. Paddy and maize each occupy about 25 per cent of the area. Wheat and pulses occupy 15 per cent each. The pattern is : Pd_4 M_4 W_4 Pu_4.

4.61 Rice yields in the zone are about the same as, all-India. In Bhagalpur district rice is almost entirely irrigated and has a Relative yield Index Value of 96 per cent. Santhal Parganas with only 11 per cent irrigation has the highest yield in the State (105 per cent). Wheat yield in Bhagalpur is low (65 per cent) of all-India. Relative Yield Index Value of Maize in Bhagalpur is 83 per cent with no irrigation.

4.62 Goats account for 31 per cent and male cattle 22 per cent of livstock population in Bhagalpur district and the pattern is : G_3 Cm_4 Cf_4/Cy_4. In Santhal parganas also population of goats is predominent and the pattern is : G_4 Cm_4 Cf_4 Cy_4.

Rainfall Zone XI—$D_1E_3(A_1B_1C_2)D_1E_3$

4.63 The zone comprises of only one sub-division of Deograh of Santhal Parganas. Its area is 2,431 sq km. The heights vary from about 400 to 750 masl and the soils are red sandy.

4.64 The zone receives annually about 120 cm. rainfall in 65 rainy days. July is the month of

maximum rainfall and with August, accounts for about 50 per cent of annual. There are only two months, July and August, with more than 20 cm pm. rainfall. September and June have less rainfall.

4.65 The zone is primarily paddy dominated with about 70 per cent area under it. The pattern is : Pd_1.

4.66 Goats are dominant with 30 per cent of the total livestock in the district and the pattern is : G_4 Cm_4 Cf_4 Cy_4.

Rainfall Zone XII—$D_1E_3(A_1B_2C_1)D_1E_3$

4.67 Madhubani sub-division of Darbhanga district constitutes this zone.

4.68 The area of the zone is 3,475 sq km. It is plain area with an elevation of about 60 masl. The soils are recent alluvial.

4.69 The annual rainfall is 132 cm in 60 rainy days. July is the month of Maximum rainfall and 50 per cent of annual precipitation is received during July and August.

4.70 Paddy area is over 60 per cent followed by pulses the cropping pattern is : Pd_2 Pu_4.

4.71 Yield of paddy in Darbhanga district is only 64 per cent of all-India. Less than 10 per cent of crop is irrigated. The low yield may be due to inadequacy of rainfall during September-October.

4.72 Darbhanga district has slightly higher percentage of male cattle (26 per cent) followed by goats (25 per cent). The pattern is : Cm_4 G_4 Cf_4 Cy_4.

Rainfall Zone XIII—$D_1E_3(A_2B_1C_1)D_1E_3$

4.73. The districts, sub-divisions and the cropping patterns in the zone are :

Cropping pattern	Sub-division	District
Pd_3 Pu_4 W_4	Muzaffarpur	Muzaffarpur
Pd_3 Pu_4 W_4	Darbhanga	Darbhanga
M_3 W_4 Pd_4	Samastipur	,,
Pd_3 Pu_4 W_4/M_4	Saharsa	Saharsa
Pd_2 M_4	Giridih	Hazaribagh

4.74 The area of the zone is 14,903 sq. km. The sub-divisions vary in are from 1,500 (Saharsa) to 5,200 sq km (Giridih).

4.75 Elevations in Giridih are 400 to 600 masl and in the rest of the zone 40 to 60 masl. The soils are recent or calcareous alluvial except for red and yellow in Hazaribagh.

4.76 Rainfall in the zone varies from 120 to 150 cm. July and August are the rainiest months with a total of about 60 cm or higher rainfall. These contribute about 50 per cent of annual rainfall.

4.77 Paddy is the dominant crop of the zone. Samastipur has been included in the maize pattern because it adjoins two sub-divisions with about 40 per cent maize. Paddy area in Giridih is 59 per cent and area of maize 10 per cent. The pattern is : Pd_2 M_4. In the rest of the sub-division paddy other pulses and wheat constitute the pattern.

4.78 Yield of rice in Darbhanga district is 64 per cent of all-India. The yield level should be better as 25 per cent of area is irrigated. Maize yield is 89 per cent and wheat yield is 75 per cent of all-India and about the same as the State average.

4.79 In Darbhanga district, livestock population has more male cattle than goats. The pattern is : Cm_4 G_4 Cf_4 Cy_4.

Rainfall Zone XIV—$D_1E_3(A_1B_2)D_1E_3$

4.80 The sub-divisions and the cropping patterns in the zone are :

Cropping pattern	Sub-division	District
Pd_1	Chaibasa	Singhbhum
	Saraikela	,,
	Jamshedpur	,,
Pd_2 Pu_4	Ranchi	Ranchi
Pd_1	Sahibganj	Santhal Parganas
Pd_2 $Pu_4/W_4/M_4/Mt_4$	Dumka	,,
Pd_1	Jamtara	,,
Pd_2 W_4	Bettiah	Champaran
	Motihari	,,
Pd_2 Pu_4	Sitamarhi	Muzaffarpur
Pd_3 Pu_4 W_4 M_4 Ju_4	Supaul	Saharsa
	Madhepur a	,,
Pd_3 Pu_4 W_4	Purnea	Purnea
	Katihar	

4.81 This is the biggest zone with an area of 50,133 sq km (nearly 30 per cent of the area of the State). The sub-divisions span 7 districts. Singhbhum and Champaran districts are fully included in the zone, along with major portions of Santhal Parganas, Purnea and Saharsa. Besides, the zone includes Ranchi and Muzaffarpur sub-divisions also.

4.82 The sub-divisions are partly in the Plateau and partly in the plains areas of the State. The elevations of the two areas are as follows :

Plain	Saharsa Purnea	30 to 65 masl
	Champaran	60 to 75 except in Battiah where maximum is 880 masl in the northwest
Plateau	Santhal Parganas	300—500 masl
	Singhbhum	400—900 masl
	Ranchi	560—1,100 masl

4.83 The plateau areas have about 40 per cent net sown area. Forests cover 10 to 25 per cent with land not available for cultivation and fallow lands forming 10 to 15 and 15 to 20 per cent respectively. Net sown area in plains is high. It is over 70 per cent in

Champaran and Muzaffarpur and 60 to 65 per cent elsewhere. Forests are almost absent. Land not available for cultivation is 15 per cent and fallow lands are 15 per cent in Saharsa and Purnea.

4.84 In the plains the soils are mostly recent alluvial with a strip of calcareous soils and terai soils in the extreme northwest in Bettiah. Soils are red sandy in Ranchi and Santhal Parganas. In Singhbhum these are red sandy with a major portion of mixed red and black. A small area of red and yellow soils is present in Jamshedpur.

4.85 The annual rainfall varies between 125 and 150 cm in 60 to 80 rainy days. July and August are the rainiest months and together contribute more than 50 per cent of total rainfall.

4.86 Paddy is the dominant crop of the zone. In the southern sub-divisions paddy occupies more than 60 per cent area : the patterns are Pd_1 in Singhbhum and Santhal Parganas except in Dumka sub-division and Pd_2 Pu_4 in Ranchi. In the northern sub-divisions, paddy is generally less than 50 per cent. The patterns are Pd_2 W_4 in Champaran, Pd_2 $Pu_4/W_4/M_4/Mt_4$ in Dumka sub-division, Pd_2 Pu_4 in Muzaffarpur, Pd_3 Pu_4 W_4/M_4 Ju_4 in Saharsa and Pd_3 Pu_4 W_4 in Purnea.

4.87 The highest rice yield is 105 per cent in Santhal Parganas. followed by 80 per cent in Singhbhum and 60 to 65 per cent in the northern most districts except Purnea which is only 45 per cent. Irrigation is negligible in most of the districts except for Champaran, Ranchi and Saharsa, which have 20 to 25 per cent of Paddy area under irrigation. The yields of wheat are nearly uniform being 70 to 75 per cent except in Champaran where yield is 89 per cent of all-India. The yields are low though irrigation is 40 per cent in Darbhanga to Purnea, 50 per cent in Champaran and 20 per cent in Muzaffarpur. Yield of total pulses in Champaran is 122 per cent of all-India; elsewhere it varies generally between 85 and 100 per cent.

4.88 Goat population is predominant in the northern-most districts except in Darbhanga and Saharsa where male cattle predominates. Goats from the Major category in the southern and eastern districts also. The patterns are :

Cm_4 G_4 Cf_4 Cy_4—Saharsa

G_4 Cm_4 Cf_4 Cy_4—Santhal Pargans and Purnea

$G3$ Cm_4 Cw_4 Cy_4/S_4—Res

Rainfall Zone XV—$C_1E_3(A_2B_2)C_1E_3$

4.89 Pakur of Santhal Parganas district is the only sub-division in this zone.

4.90 The area of the zone is 1,782 sq km. The elevations range between 275 and 570 masl. The soils are red sandy.

4.91 The annual rainfall is 160 cm in about 80 rainy days. The maximum rainfall occurs during the months of July and August. All the six months from May to October get more than 10 cm rainfall per month. Both July and August receive higher than 30 cm of rainfall.

4.92 Paddy is cultivated on 73 per cent of area followed by maize (9 per cent) and other pulses (9 per cent). The pattern is : Pd_1.

4.93 Santhal Parganas district has the highest rice yield in the State being 105 per cent of all-India. Irrigation is only 11 per cent. Rainfall of October (being higher than 10 cm) has to some extent helped in lessening water stress during this period. Maize yield under such good rainfall conditions is only 69 per cent and yield of pulses is 90 per cent.

4.94 Goats constitue about 30 per cent of livestock population. Goats and cattle account for 75 per cent in Santhal Parganas district. The pattern is : G_4 Cm_4 Cf_4 Cy_4.

Rainfall Zone XVI—$C_1E_3(A_3B_1)C_1E_3$

4.95 Araria is the only sub-division of Purnea included in the zone and its cropping pattern is Pd_1 Ju_4.

4.96 Area of the zone is 2666 sq km. The elevation is 45-60 masl and the soils are recent alluvial.

4.97 This is a zone of good rainfall with about 170 cm rainfall in 73 rainy days. Nearly 50 per cent of the annual rainfall is in July and August. July to September receive more than 30 cm pm rainfall.

4.98 Paddy covers 55 per cent of area followed by jute (11 per cent) pulses and wheat (7-8 per cent each). Though paddy and jute add up to a few per cent less than 70, it is combined with adjoining Kishanganj which has about 70 per cent jute area.

4.99 Yield of Paddy in Purnea district is the lowest in the State, being less than 50 per cent of all-India. Irrigation is hardly 10 per cent and negligible but rainfall is good.

4.100 Livestock pattern of Purnea district is : G_4 Cm_4 Cf_4 Cy_4.

Rainfall Zone XVII—$C_1E_3(A_4)D_1E_3$.

4.101 The zone includes Kishanganj sub-division.

4.102 The area of the zone is 1934 sq. cm. The elevations range from 60 to 80 masl and the soils are recent alluvail.

4.103 The zone has the heaviest rainfall in the State. The annual rainfall being over 200 cm. July and August rainfall total to about 100 cm. All the months June to September get more than 30 cm pm rainfall. May rainfall is 10 cm or higher.

4.104 Paddy occupies 70 per cent of the area followed by jute with 18 per cent. Along with adjoining sub-division of Araria the pattern is : Pd_2 Ju_4. This is one of the very few sub-divisions with jute as a significant crop. Purnea district has the largest jute area in the State.

4.105 Yield of paddy in Purnea district is the lowest in the State being only 45 per cent of all-India. Though rainfall in this zone is adequate for growing a crop like rice, the yield is low. Jute is grown on 10 per cent of the cropped area of the district with yield of 71 per cent of all-India. This yield is also low.

5 FUTURE CROPPING PATTERNS—SOME OBSERVATIONS

General

5.1 In the foregoing sections we have dealt with in detail the rainfall, cropping and livestock patterns which emerge from the existing information. We have also categorised the rainfall patterns into zones and discussed how the other patterns feature in those zones. Among other information that on soils, which ought to play an important role in determining cropping patterns, is lacking in such details as are wanted for this analysis. Data on orography and population density have featured in this analysis but their exact role on cropping and livestock patterns could not be brought out owing to lack of detailed information. We are, however, convinced that studies and analysis indicated in the preceding sections are important for the guidance they may give in deciding cropping and livestock patterns vis a vis rainfall patterns. The greater the accuracy of the primary information, and the more detailed such information is, the more useful the data would be in drawing up the most efficient cropping and livestock patterns in an area or a zone. With this purpose in view the following procedures are suggested :

    (i) Delineation of rainfall zones;

    (ii) Identification of the existing cropping patterns;

    (iii) Assessment of area needed for each crop and its ideal distribution;

    (iv) Comparison of (iii) with (ii) in order to determine possible changes; and

    (v) Consideration of other related factors like soil, irrigation facilities, density of population, livestock patterns and then arriving at the future cropping patterns.

5.2 The methods of delineating rainfall patterns or zones and cropping patterns have been fully discussed in Section 2. For purpose of locating suitable areas for a crop, soil and topography of the land are important factors. The approximate area to be put under each crop will be decided by the demand not only at a State level but at a national level, either for internal consumption or for the purpose of export. The departments responsible for crop planning in the State should, therefore, be cognisant of the demand for a crop, so that production efforts are not rendered futile because of lack of demand and marketing. We have already discussed the part each of the factors mentioned in item (v) of para 5.1 is likely to play in deciding cropping patterns. For this purpose not only detailed data but also knowledge about the correlation between these factors and crop performance would be necessary. Knowledge gained, through long experience, by farmers would also be most helpful.

5.3 We ought to mention that the rainfall intervals which form the basis of identifying rainfall patterns are subject to minor modifications. Thus, the condition that 30 cm of rainfall for three consecutive months is good for paddy may not be rigorously adhered to. If the soil is favourable with a high water retention capacity or, what is more important water management is efficient with an eye to economise water use, rainfall lower than 30 cm for three months may sustain a good crop of paddy.

5.4 The choice of a cropping pattern is not decided by the farmer only on technical grounds. He is also guided by the profitability of the crops or requirements for his household consumption. Farmers may not be inclined to accept a crop unless the necessary inputs and infrastructure are assured. Of all the inputs water is the most important as is made evident by the spread of groundnut in the country, sugarcane in Gujarat, maize and cotton in Karnataka and recently of wheat in West Bengal. These are excellent instances of the manner of introduction of new crops in the cropping patterns of a State or a region.

Some Observations Pertaining to Bihar

5.5 The yields of rice, wheat, sugarcane, barley, gram, jute and maize are below the all-India level in many parts of the State. There appears to be very good scope to improve the yield standards. In relation to crop production, the main problem relates to water management. In general, the amount of rainfall received in the four months of south-west monsoon is either of $A_2 B_1$ or $A_1 B_2$ or $A_2 B_2$ categories. This much could be considered adequate for many crops. The months of May and October also receive rainfall of D type in many places. Howevery, the rainfall of pre and post-monsoon months is not very dependable.

5.6 Approximately, the Latitude 25°N divides the State into two halves. The upper half is predominated by Gangetic alluvium while the southern half has soils characteristics of the central plateau. The four types of main rainfall patterns covering the period, May to October, are indicated below :

Rainfall pattern during the period May to October	Number of sub-divisions	
	north of L 25° N	south of L 25° N
$D_1/E_1 A_2 B_2 D_1$.	4	8
$D_1/E_1 A_2 B_1 C_1 D_1$	7	11
$D_1/E_1 A_1 B_2 C_1 D_1$	6	1
$D_1/E_1 A_1 B_1 C_2 D_1$	1	1
	18	21

5.7 The total number of sub-divisions covered by the above mentioned patterns are 39, representing about 67 per cent of all the sub-divisions of the State. Southern Bihar below L25°N has 19 sub-divisions in

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A_2 B_2 and A_3 B_1 categories of rainfall in south-west monsoon months whereas the northern parts have only 11, which should suffice to indicate that southern Bihar is as good as north Bihar sofar as the rainfall is concerned.

5.8 The crop of rice is taken throughout the State, but it suffers heavily in the northern districts of Saharsa, Purnea, Darbhanga, Muzaffarpur and Champaran from riverine floods. The floods are more or less an annual feature and, therefore, it is worthwhile considering whether it is advisable at all to grow rice in the areas adjacent to the northern tributaries of the Ganga. It would be probably advantageous to readjust cropping patterns *vis-a-vis* paddy throughout the State. Emphasis on entire kharif cropping should be in the areas to the south of the Ganga. The soils in plateau areas are not as fertile as in the north. But this disadvantage could be overcome by the use of required doses of manures and fertilisers. By adopting improved technology relating to crop production including increasing use of plant protection measures, it should be quite possible to achieve much higher production levels of kharif crops including rice even with the exclusion of the intensely flood prone areas of the north. Alternate cropping patterns should be conceived and tested for their suitability in different regions. In the new scheme it should be seen that rice crop is confined throughout the State to the low lying areas or where it is possible to ensure a constant supply of irrigation water. All other areas must be diverted from paddy to comparatively less water requiring crops like maize, soyabean and urid or similar crops. Sugarcane area can be increased and so also the area under various oilseeds. Niger could be popularised during kharif season and safflower during rabi after paddy.

5.9 In riverine tracts of the north, crops could be grown during rabi and summer season in general with the exception of jute. Summer cropping should not be difficult in the receding riverbeds and in other neighbouring areas with the help of irrigation from wells.

5.10 Jute should be continued to be grown in northern districts, specially Saharsa and Purnea. The farmers are aware that, if the jute crop has attained an age of about two months before heavy rainfall occurs, it is able to withstand the same, barring of course, situations where the crop is liable to be washed away altogether. It should be feasible to start the crops of jute in the month of May with the support of premonsoon rains and/or irrigation. If the crop could be sown in May, it is possible to achieve the objective mentioned earlier. Farmers do adopt this approach wherever feasible, but this practice has to be scientifically established and popularised.

APPENDIX 1

Districtwise Livestock Population—1966

BIHAR

(Thousands)

District	Cattle			Buffaloes			Sheep	Goats	Horses & ponies	Mules	Donkeys	Camels	Pigs	Total livestock
	Male	Female	Young stock	Male	Female	Young stock								
1 Bhagalpur	235	159	186	30	54	41	22	331	6	—	—	—	11	1075
	(22)	(15)	(17)	(3)	(5)	(4)	(2)	(31)	(—)	(—)	(—)	(—)	(1·0)	
2 Champaran	416	205	178	16	109	89	15	542	5	—	3	—	13	1591
	(26)	(13)	(11)	(1)	(7)	(6)	(1)	(34)	(—)	(—)	(0·2)	(—)	(1)	
3 Darbhanga	468	280	282	1	153	109	10	438	6	—	1	—	11	1759
	(26)	(16)	(16)	—	(9)	(6)	(1)	(25)	(—)	(—)	(—)	(—)	1	
4 Dhanbad	128	90	87	37	12	6	82	133	—	—	—	—	16	591
	(22)	(15)	(15)	(6)	(2)	(1)	(14)	(22)	(—)	(—)	(—)	(—)	(3)	
5 Gaya	586	301	336	93	166	142	131	484	2	—	1	—	69	2311
	(25)	(13)	(15)	(4)	(7)	(6)	(6)	(21)	(—)	(—)	(—)	(—)	(3)	
6 Hazaribagh	439	321	402	148	53	38	57	544	2	—	—	—	57	2061
	(21)	(16)	(19)	(7)	(3)	(2)	(3)	(26)	(—)	(—)	(—)	(—)	(3)	
7 Monghyr	366	269	291	31	88	64	26	483	8	—	—	—	30	1657
	(22)	(16)	(18)	(2)	(5)	(4)	(2)	(29)	(0·5)	(—)	(—)	(—)	(2)	
8 Muzaffarpur	470	191	177	2	138	97	11	608	4	—	5	—	7	1709
	(28)	(11)	(10)	—	(8)	(6)	(1)	(36)	(—)	(—)	(—)	(—)	(—)	
9 Palamau	308	217	198	11	68	44	71	248	7	—	—	—	27	1198
	(26)	(18)	(16)	(1)	(6)	(4)	(6)	(21)	(—)	(—)	(—)	(—)	(2)	
10 Patna	276	120	150	27	129	110	25	263	5	—	2	—	27	1134
	(24)	(11)	(13)	(2)	(12)	(10)	(2)	(23)	(1)	(—)	(—)	(—)	(2)	
11 Ranchi	483	301	246	140	53	40	120	676	4	—	—	—	91	2154
	(22)	(14)	(11)	(7)	(3)	(2)	(6)	(31)	(—)	(—)	(—)	(—)	(4)	
12 Saharsa	342	265	236	4	104	79	4	293	16	—	—	—	8	1351
	(25)	(20)	(19)	—	(8)	(6)	—	(22)	(1)	(—)	(—)	(—)	(1)	
13 Santhal Pargana	535	410	373	90	80	66	243	845	8	—	—	—	196	2846
	(19)	(14)	(13)	(3)	(3)	(2)	(9)	(30)	(—)	(—)	(—)	(—)	(7)	
14 Saran	335	155	164	—	130	86	31	419	7	—	12	—	12	1352
	(25)	(12)	(12)	(—)	(10)	(6)	(2)	(31)	(0·4)	(—)	(0·9)	(—)	(0·9)	
15 Shahabad	457	247	240	1	193	142	125	202	7	—	8	—	23	1645
	(28)	(15)	(15)	(—)	(12)	(9)	(8)	(12)	(1·4)	(—)	(0·5)	(—)	(1·4)	
16 Singhbhum	426	238	195	68	16	10	261	558	—	—	—	—	26	1797
	(24)	(13)	(11)	(4)	(1)	(31)	(14)	(3)	(—)	(—)	(—)	(—)	(1)	
17 Purnea	659	337	380	34	117	97	14	733	28	—	—	—	21	2420
	(27)	(14)	(16)	(1)	(5)	(4)	(1)	(30)	(1·1)	(—)	(—)	(—)	(0·9)	

NOTE : Figures in brackets represent percentages to total livestock.

18

Rainfall and Cropping Patterns—BIHAR
BIHAR

| Cropping patterns | District | Sub-division | Area in sq km | Elevation (masl) | | Annual total rainfall (cm) | Annual number of rainy days | Month of maximum rainfall | Rainfall in Consecutive months* two consecutive months including the month of maximum plus the preceding or succeeding month which ever is higher | | (a) | (b) | (c) |
				max	min				cm	No. of rainy days			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rainfall Zone—I			..	..	..	..	..	..	*Rainfall Pattern—$E_4(B_2C_2)E_4$*				
Pd_3W_4	Patna	Bihar	2079	119	48	105	52	8	59	27	6—4	91	42
$Pu_3Pu_4W_4$		Barh	1425	119	48	96	51	8	50	25	6—4	83	41
Rainfall Zone—II			..	..	..	..	..	..	*Rainfall Pattern—$E_4(B_2C_2)D_1K_3$*				
$Pd_4M_4W\,Ba_4$	Saran	Chapra	2665	77	68	105	53	8	57	27	6—4	91	43
Rainfall Zone—III			..	..	..	..	..	..	*Rainfall Pattern—$E_4(A_1B_1C_2)E_4$*				
Pd_2Pu_4	Gaya	Nawada	2629	667	446	103	57	8	58	29	6—4	88	46
Rainfall Zone—IV			..	..	..	..	..	..	*Rainfall Pattern—$E_4(A_1B_1C_2)E_4$*				
$Pd_4M_4W_4Pu_4$	Muzaffarpur	Hajipur	2012	51	46	108	54	8	58	27	6—4	94	44
Rainfall Zone—V			..	..	..	..	..	..	*Rainfall Pattern—$E_4(A_1B_2C_1)E_4$*				
Pd_2Pu_4/W_4	Gaya	Jehanabad	1420	310	94	109	55	8	63	28	6—4	95	44
Rainfall Zone—VI			..	..	..	..	..	..	*Rainfall Pattern—$E_4(A_1B_2C_1)D_1E_3$*				
$Pd_4M_4W_4S_4/Ba_4$	Saran	Gopalganj	2019	76	68	110	52	7	58	26	6—4	94	41
$M_3W_4Pd_4$	Monghyr	Begusarai	1921	48	37	120	60	8	60	29	6—4	102	38
$Pd_3Pu_4W_4$		Monghyr	2885	252	50	115	58	8	59	29	6—4	97	47
$M_3W_4Pd_4$		Khagaria	1472	40	36	—	—	—	—	—	—	—	—
$Pd_2Pu_4/W_4/M_4/Mt_4$		Jamui	3377	651	252	114	60	8—7	59	30	6—4	96	48
$Pd_3Pu_4/W_4/M_4/Ju_4$	Shahabad	Buxar	1551	89	71	105	51	8	60	27	6—4	92	42
Pd_3Pu_4	Patna	Patna sadar	136	48	47	117	56	8	62	27	6—4	101	45
		Patna city	664	48	47	—	—	—	—	—	—	—	—
		Dinapur	1126	48	47	108	51	8	59	26	6—4	94	42
Rainfall Zone—VII			..	..	..	..	..	..	*Rainfall Pattern—$E_4(A_2B_1C_1)E_4$*				
Pd_2W_4/Pu_4	Gaya	Gaya	4950	545	266	118	60	8	70	32	6—4	104	49

* =Consecutive months with rainfall of more than 10 cm per month.

a =Initial month with more than 10 cm of rainfall and number of consecutive months with more than 10 cm per month separated by hyphen.

b =Total rainfall of consecutive months under 'a' in cm.

c =Total number of rainy days of consecutive months under 'a'.

masl=metres above sea level.

NOTES : 1 Information on rainfall and rainy days based on Memoirs of India Meteorological Department, Vol. XXXI Part III.

2 For explanation of coded form of rainfall and cropping patterns, reference may be made to section 2 in the text.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Rainfall Zone—VIII		..	..	..	..	..				..*Rainfall Pattern —$E_4(A_2B_1C_1)D_1E_3$*		
$Pd_4M_4W_4Pu_4/Ba_4/S_4$	Saran	Siwan	2280	77	68	116	55	7	64	28	6—4	100	44
$Pd_3W_4Pu_4$	Shahabad	Arrah	2254	84	58	117	58	8	65	30	6—4	101	47
Pd_3W_4	,,	Sasaram	3425	460	85	123	57	8	71	30	6—4	107	46
	,,	Bhuaba	3594	440	325	116	56	8	66	30	6—4	101	46
Pd_2W_4/Pu_4	Gaya	Aurangabad	3253	225	94	126	56	8	74	30	6—4	111	46
$Pd_3M_4Pu_4O_4$	Palamau	Garshwa	4051	569	139	121	62	8—7	68	31	6—4	103	49
	,,	Daltonganj	4308	584	139	124	64	8	71	33	6—4	106	50
	,,	Latehar	3663	1022	360	132	67	8—7	73	32	6—4	111	52
$Pd_2W_4/Pu_4/M_4/Mt_4$	Hazaribagh	Chatra	4002	767	461	134	67	8	75	34	6—4	115	52
		Hazaribagh	8598	975	308	134	75	8	67	35	6—4	108	57
Pd_1	Dhanbad	Dhanbad	1403	745	360	131	72	8—7	67	34	6—4	108	55
		Baghmara	1555	745	360	113	61	7—8	57	30	6—5	101	52
$Pd_2W_4/Pu_4/M_4/Mt_4$	Ranchi	Simdega	3761	675	491	158	84	7	91	41	6—4	134	66
	Rainfall Zone—IX		..	..	..	..	..		.. *Rainfall Pattern—$E_4(A_2B_2)D_1E_3$*				
Pd_2Pu_4	Ranchi	Gumla	5321	1102	656	147	82	7	76	38	6—4	119	62
		Khunti	3533	796	450	161	83	8	86	38	6—5	142	68
	Rainfall Zone—X		..	..	..	..	..		..*Rainfall Pattern—$D_1E_3(B_2C_2)D_1E_3$*				
$Pd_4M_4W_4Pu_4$	Bhagalpur	Bhagalpur	2377	399	55	108	57	8	51	27	6—4	88	45
Pd_2Pu_4		Banka	3021	399	55	120	62	7	58	29	6—4	97	49
	Santhal-Parganas	Godda	2274	567	154	109	62	7	50	28	6—4	87	48
	Rainfall Zone—XI		..	..	..	..	..		*Rainfall Pattern—$D_1E_3(A_1B_1C_2)D_1E_3$*				
Pd_1	Sanghal-Parganas	Deogarh	2431	753	391	122	66	7	58	31	6—4	97	51
	Rainfall Zone—XII		..	..	..	..	..		*Rainfall Pattern—$D_1E_3(A_1B_2C_1)D_1E_3$*				
Pd_2Pu_4	Darbhanga	Madhurbani	3475	69	54	132	60	7	67	27	6—4	111	56
	Rainfall Zone—XIII		..	..	..	..	..		*Rainfall Pattern—$D_1E_3(A_2B_1C_1)D_1E_3$*				
$Pd_3Pu_4W_4$	Muzaffarpur	Muzaffarpur	3101	59	50	121	56	8—7	64	27	6—4	104	45
	Darbhanga	Darbhanga	2264	47	43	126	57	8	65	27	6—4	107	45
$M_3W_4Pd_4$		Samastipur	2870	45	43	148	60	8	78	30	6—4	128	49
$Pd_3Pu_4W_4/M_4$	Saharsa	Saharsa	1491	56	48	—	—	—	—	—	—	—	—
Pd_2M_4	Hazaribagh	Giridih	5177	605	388	—	—	—	—	—	—	—	—
	Rainfall Zone—XIV		..	..	..	..	..		.. *Rainfall Pattern—$D_1E_3(A_2B_2)D_1E_3$*				
Pd_2W_4	Champaran	Bettiah	4298	830	72	125	54	7—8	67	26	6—4	106	43
	,,	Motihari	3956	75	65	131	57	7	70	27	6—4	112	45
Pd_2Pu_4	Muzaffarpur	Sitamarhi	2507	70	58	139	58	7	69	26	6—4	116	44
Pd_1	Singhbhum	Chaibasa	5206	918	561	132	75	7	65	33	6—4	104	55
	,,	Seraikela	7577	538	423	131	68	8—7	66	31	6—4	104	51
	,,	Jamshedpur	3554	926	524	144	78	7—8	73	35	6—4	117	57
Pd_2Pu_4	Ranchi	Ranchi	5394	1057	661	151	81	7	77	37	6—4	122	60
$Pd_3Pu_4W_4/M_4Ju_4$	Saharsa	Supaul	2375	65	48	140	61	7	66	28	6—4	116	47
	,,	Madhepura	1649	43	136	137	60	7	66	27	6—4	113	47
$Pd_3Pu_4W_4$	Purnea	Purnea	3180	45	33	149	71	7	70	32	5—5	132	61
		Katihar	3008	45	33	—	—	—	—	—	—	—	—
Pd_1	Santhal-Parganas	Sahibganj	1979	440	363	140	65	8—7	63	30	6—5	124	55
$Pd_2Pu_4/W\ M_4/Mt_4$	Dumka		3678	506	330	—	—	—	—	—	—	—	—
Pd_1		Jamtara	1772	474	296	138	74	8—7	65	34	6—4	111	58
	Rainfall Zone—XV		..	..	..	..	..		.. *Rainfall Pattern—$C_1E_3(A_2B_2)C_1E_3$*				
Pd_1	Santhal-Parganas	Pakur	1782	567	276	158	78	8—7	69	34	5—6	147	70
	Rainfall Zone—XVI		..	..	..	..	..		*Rainfall Pattern—$C_1E_3(A_3B_1)D_1E_3$*				
Pd_2Ju_4	Purnea	Araria	2666	62	45	169	73	7	80	33	5—5	153	63
	Rainfall Zone—XVII		..	..	..	..	..		*Rainfall Pattern—$C_1E_3(A_4)D_1E$*				
Pd_2Ju_4	Purnea	Kishanganj	1934	77	60	218	79	7	102	34	5—6	206	72

APPENDIX 3

Area under Principal Crops (per cent of Gross Cropped Area)—1969-70

BIHAR

District/Sub-division	Gross cropped area (000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Patna — *Rainfall Zone—I* — *Rainfall Pattern—E₄(B₂C₂)E₄*																						
Bihar	248·9	46	—	..	—	7	1	10	1	..	3	0·3	24	0·1	—	1	—	—	4	—	—	6
Barh	161·1	24	—	..	—	11	—	14	1	0·3	9	1	33	0·1	—	2	—	—	1	—	—	4
Saran — *Rainfall Zone—II* — *Rainfall Pattern—E₄(B₂C₂)D₁E₁*																						
Chapra	246·9	27	—	—	—	25	1	16	7	2	3	5	3	2	—	1	0·2	—	0·1	—	—	8
Gaya — *Rainfall Zone—III* — *Rainfall Patterns—E₄(A₁B₁)C₂E₄*																						
Nawadah	201·1	47	—	..	0·1	2	2	11	1	—	3	1	29	..	0·1	1	—	0·1	—	—	—	—
Muzaffarpur — *Rainfall Zone—IV* — *Rainfall Paterns—E₄(A₁B₁C₂)E₄*																						
Hajipur	231·1	28	—	—	—	21	1	12	7	1	1	2	10	2	—	1	—	—	0·3	2	—	13
Gaya — *Rainfall Zone—V* — *Rainfall Patterns—E₄(A₁B₂C₁)E₄*																						
Jehanabad	144·1	66	—	—	—	2	—	8	1	—	2	..	13	2	—	1	—	—	0·2	—	—	3
Saran — *Rainfall Zone—VI* — *Rainfall Patterns—E₄(A₁B₂C₁)D₁E₃*																						
Gopalganj	199·9	32	—	—	—	17	1	17	7	3	1	4	3	8	—	1	—	—	0·1	0·1	0·1	6
Monghyr																						
Begusarai	171·2	8	—	—	—	41	1	21	2	1	6	3	4	2	—	1	—	—	0·2	—	—	10
Monghyr	231·9	36	—	—	—	9	0·3	14	2	1	11	1	18	0·4	—	1	—	—	0·1	—	—	7
Khagaria	120·2	13	0·1	—	—	38	0·3	19	3	2	4	2	14	0·3	—	1	—	—	0·4	—	—	3
Jamui	138·0	64	—	—	0·1	8	0·1	5	2	1	2	2	12	1	—	1	—	—	—	—	—	2
Shahabad																						
Buxar	214·5	43	1	—	1	3	—	24	2	1	4	1	14	1	—	2	—	—	0·3	—	—	3
Patna																						
Patna Sadar	100·8	47	—	—	—	2	0·1	8	8	—	3	0·3	33	0·4	—	1	—	—	0·4	—	—	5
Dinapur	141·9	43	—	—	0·3	7	0·2	10	2	1	3	4	25	2	—	1	—	—	1	—	—	4
Gaya — *Rainfall Zone—VII* — *Rainfall Pattern—E₄(A₂B₁C₁)E₄*																						
Gaya	343·6	56	—	..	—	3	1	13	1	—	3	1	15	2	—	2	—	—	0·1	—	—	3

Pd=paddy
Jk=jowar kharif
Jr=jowar rabi
B=bajra

M=maize
R=ragi
W=wheat
Ba=barley
Mt=small millets

G=gram
T=tur
Pu=other pulses
S=sugarcane
Gn=groundnut

O=other oilseeds
C=cotton
L=plantations
F=fodder
Misc.—miscellaneous crops

To=tobacco
Ju=jute

NOTE : The percentage figures have been rounded off individually and hence cross totals may not, in some cases, add upto 100.

APPENDIX 3 (Contd.)

District/Sub-division	Gross cropped area ('000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Saran	*Rainfall Zone—VIII*																					
Siwan	218.9	29	—	[		18	2	15	11	3	2	5	3	5	—	1	0.1	—	—	0.1	1	6
Shahabad																						
Arrah	288.9	40	1	—	0.4	3	0.1	22	2	1	6	1	16	1	—	2	—	—	—	—	—	4
Sasaram	397.4	49	—	—	—	1	0.1	26	1	0.1	2	1	15	1	0.1	2	—	—	0.4	—	—	2
Bhabua	232.7	42	0.1	—	0.2	1	0.1	25	1	1	7	1	15	1	—	3	—	—	1	—	—	2
Gaya																						
Aurangabad	273.2	52	—	—	—	1	0.4	15	1	—	4	1	20	1	—	2	0.2	—	0.1	—	—	2
Palamau																						
Garhwa	107.6	26	0.1	—	0.1	14	1	4	7	12	7	7	8	1	—	11	—	—	—	—	—	2
Daltanganj	126.3	37	—	—	0.1	13	1	6	4	4	5	6	12	2	—	8	—	—	—	—	—	2
Latehar	75.3	34	0.2	—	—	19	2	1	2	15	1	4	8	0.1	—	12	0.1	—	—	—	—	2
Hazaribagh																						
Chatra	65.6	56	0.2	—	—	14	3	4	2	3	1	2	7	1	—	4	—	—	—	—	—	3
Hazaribagh	206.0	59	1	—	—	12	5	0.2	0.2	7	0.4	1	6	1	—	3	—	—	—	—	—	6
Dhanbad																						
Dhenbad	48.6	79	—	—	1	—	3	0.3	—	—	—	0.1	3	0.1	—	1	—	—	—	—	—	3
Baghmara	45.7	79	—	—	0.2	—	4	0.1	—	—	0.1	0.3	4	0.1	—	1	—	—	—	—	—	5
Ranchi																						
Simdega	150.5	59	0.2	—	0.2	—	5	0.2	—	13	1	1	12	—	0.2	5	0.2	—	—	—	—	2

Rainfall Pattern—E4 (A2B2) D1 E3

District/Sub-division	Gross cropped area ('000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Ranchi	*Rainfall Zone—IX*																					
Gumla	220.1	56	—	—	—	1	7	0.3	0.1	9	1	3	12	—	0.1	—	0.1	—	—	—	—	9
Khunti	159.4	61	—	—	—	1	6	0.2	—	10	1	4	8	—	—	5	—	—	—	—	—	4

Rainfall Pattern—D1 E3 (B2C2) D1E3

District/Sub-division	Gross cropped area ('000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Bhagalpur	*Rainfall Zone—X*																					
Bhagalpur	208.0	26	—	—	—	23	—	15	6	1	6	1	15	2	—	2	—	—	—	—	—	3
Banka	184.5	62	—	—	—	5	0.2	3	3	1	3	1	17	1	—	2	—	—	0.1	—	—	2
Santhal Parganas	*Rainfall Zone—XI*																					
Godda	129.1	63	—	—	1	10	0.3	1	2	1	2	1	14	0.3	—	2	—	—	—	—	—	2

Santhal Parganas

Rainfall Pattern—D1E3 (A1B1C2) D1E3

District/Sub-division	Gross cropped area ('000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Deogarh	93.5	71	—	—	0.4	7	1	1	—	4	0.4	0.4	14	—	0.1	1	—	—	—	—	1	

Dharbhanga — *Rainfall Zone—XII*

Rainfall Pattern—D1E3 (A1B2C1)D1E3

District/Sub-division	Gross cropped area ('000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Madhubani	304.3	64	—	—	—	2	5	6	2	—	1	1	8	2	—	1	1	—	0.1	—	—	7

Muzaffarpur — *Rainfall Zone—XIII*

Rainfall Pattern—D1E3(A2B1C1)D1E3

District/Sub-division	Gross cropped area ('000 ha)	Pd	Jk	Jr	B	M	R	W	Ba	Mt	G	T	Pu	S	Gn	O	C	L	F	To	Ju	Misc.
Muzaffarpur	277.2	39	—	—	—	13	1	10	7	1	0.3	2	13	1	—	1	—	—	0.2	0.4	0.2	11
Darbhanga																						
Darbhanga	210.8	51	—	—	—	7	6	10	2	—	2	2	10	2	—	2	—	—	—	0.4	0.1	6
Samastipur	297.0	26	—	—	—	27	1	14	3	0.4	1	3	5	2	—	2	—	—	0.2	—	—	15

23

Place																						
Saharsa — Saharsa	136·0	41	—	—	—	—	—	16	4	10	2	1	1	17	0·3	1	—	—	—	—	2	5
Hazaribagh — Giridih	126·3	59	2	—	—	—	—	9	2	1	6	1	6	8	0·3	1	—	—	—	—	—	2
Rainfall Zone—XIV							..							..						*Rainfall Pattern—D₁E₃ (A₂B₂) D₁E₃*		
Champaran — Bettiah	446·0	54	—	—	—	—	—	5	0·1	14	5	1	1	5	0·2	1	1	—	—	—	1	3
Motihari	458·1	49	—	—	—	—	—	6	0·2	15	7	1	1	7	3	1	1	—	—	—	1	7
Muzaffarpur — Sitamarhi	285·7	56	—	—	—	—	—	3	2	6	3	1	1	15	2	1	—	0·1	0·1	—	0·1	8
Singhbhum — Chaibasa	190·2	82	—	1	—	—	—	2	0·4	0·4	—	3	1	6	1	0·4	—	—	—	—	1	1
Seraikela	121·4	87	—	0·3	—	—	—	3	—	0·3	—	2	1	3	0·1	0·1	—	—	—	—	2	2
Jamshedpur	125·9	86	—	0·3	—	—	—	3	—	—	—	2	0·3	4	0·3	0·3	—	—	—	—	3	3
Ranchi — Ranchi	251·3	62	—	0·1	—	—	—	4	8	1	0·1	5	0·4	8	—	0·4	0·1	—	—	—	—	8
Saharsa — Supaul	167·2	49	—	—	—	—	—	5	5	10	2	4	—	12	0·2	0·2	1	—	—	—	1	6
Madhepura	179·7	40	—	—	—	—	—	16	3	8	2	3	0·1	14	0·2	0·2	1	—	—	—	1	7
Purnea — Purnea	312·0	49	—	—	—	—	—	8	0·4	9	2	0·4	1	10	0·4	—	4	—	—	—	9	7
Katihar	212·5	54	—	—	—	—	—	6	0·2	10	5	1	2	11	0·3	—	4	—	—	—	9	—
Santhal Parganas — Sahibganj	80·1	71	—	1	—	—	—	6	—	3	2	1	2	10	1	—	1	—	—	—	1	1
Dumka	157·8	64	—	1	—	—	—	10	0·3	0·3	—	6	0·3	14	1	—	1	—	—	—	2	2
Jamtara	68·8	88	—	1	—	—	—	4	1	—	—	1	—	4	1	—	1	—	—	—	1	1
Rainfall Zone—XV			..		..			..		..				..					*Rainfall Pattern—C₁E₃ (A₂B₂) C₁E₃*		
Santhal Parganas — Pakur	103·6	73	—	2	—	—	—	9	—	1	1	0·3	1	9	1	—	2	—	—	—	—	1
Rainfall Zone—XVI			..		..			..		..				..					*Rainfall Pattern—C₁E₃ (A₃B₁) D₁E₃*		
Purnea — Araria	256·6	55	—	—	—	—	—	1	1	8	1	0·2	8	7	0·2	—	2	—	1	—	11	13
Rainfall Zone—XVII			..		..			..		..				..					*Rainfall Pattern—C₁E₃ (A₄) D₁E₃*		
Purnea — Kishanganj	156·2	70	—	0·3	0·3	—	1	0·3	0·3	1	1	0·3	—	2	—	—	—	2	—	—	18	5

	R	Cotton	
	B	Groundnut	Gn
llets	Mt	Other oilseeds	O
harif)	Jk	Sugarcane	S
bi)	Jr	Barley	Ba
	M	Tobacco	To
	W	Jute	Ju

ng pattern consists of one or more crops, each ubscript which indicates the percentage area of concerned. The total area of the crops is about 70% r.

t

Percent of Gross cropped area

greater than 70

50 - 70

30 - 50

10 - 30

less than 10

Pattern		Area percent
$Pu_4 W_4$	Paddy	30 - 50
	Other Pulses	10 - 30
	Wheat	10 - 30

Sahibganj

A

G

Pd I

Z

Pakaur

E

B
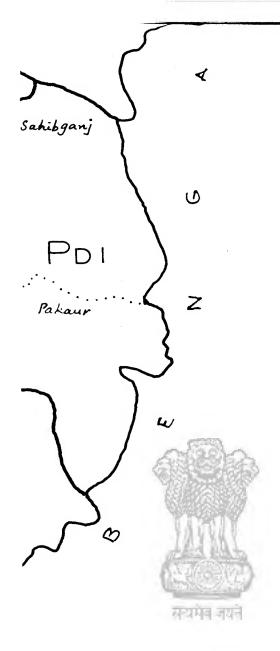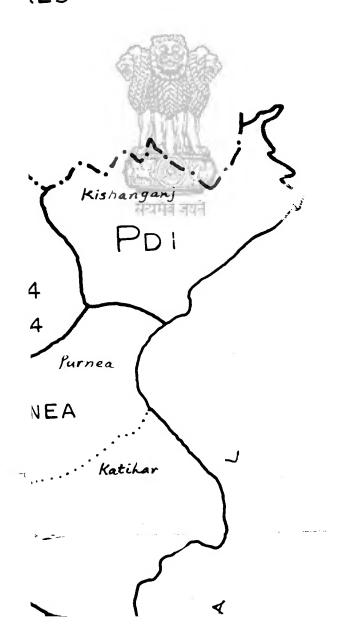
LEGEND

	Symbols	Crops	Symbols
	Pd	Gram	G
	L	Tur	T
ons	F	Other pulses	Pu
	R	Cotton	C
	B	Groundnut	Gn
llets	Mt	Other oilseeds	O
harif)	Jk	Sugarcane	S
abi)	Jr	Barley	Ba
	M	Tobacco	To
	W	Jute	Ju

ng pattern consists of one or more crops, each
ubscript which indicates the percentage area of
concerned. The total area of the crops is about 70%
r.

t of Gross cropped area

RNS

RES

Kishanganj

PD1

4

4

Purnea

NEA

Katihar

Jamtara

PDI

Dhanbad

DHANBAD

T

S

Baghmara

E

W

eraikela

Jamshedpur

SINGHBHUM

LE

Crops	Symbols
Paddy	Pd
Plantations	L
~~Fodder~~	F
Ragi	R
Bajra	B
Small Millets	Mt
Jowar (Kharif)	Jk
Jowar (Rabi)	Jr
Maize	M
Wheat	W
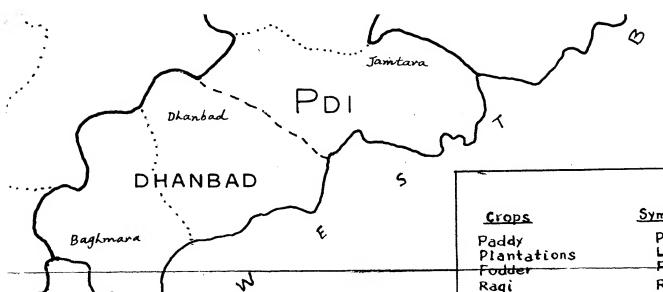
A cropping pattern consist.
with a subscript which in
the crop concerned. The tot
or higher.

Subscript	Pe
1	
2	
3	
4	
5	

Example:

Pattern

$Pd_3 Pu_4 W_4$

Begusarai

Monghyr

MONGHYR

Pu4W4/M4

Jamui

MT4/W4

Bhagalpur

Pd4M4Pu4W4

Sahibganj

Banka

BHAGALPUR

Godda

Pd1

Pakaur

Deogarh

Dumka

SANTAL PARGANAS

A

Jamtara

Pd1

Dhanbad

DHANBAD

Baghmara

S

T

B

W

E

W

Somibola

Crops	Symbols
Paddy	Pd
Plantations	L
Fodder	F
Ragi	R
Bajra	B
Small Millets	Mt
Jowar (Kharif)	JK
Jowar (Rabi)	Jr
Maize	M
Wheat	W

A cropping pattern consi
with a subscript which
the crop concerned. The t
or higher.

BIHAR
CROPPING PATTERNS

MILES 16   0   16   32   48   64

16 0 16   48   80   K.METRES

P

A

Madhubani

W4

L

Supaul

Araria

Kishanganj

PD1

DARBHANGA

SAHARSA

PD2 PU4
/W4/JU4

PD3 PU4 W4/M4/JU4

Madhepura

Saharsa

Purnea

PURNEA

W4 PD4

Khagaria

Katihar

Begusarai

Monghyr

Bhagalpur

Ranchi

nla

RANCHI

Khunti

Seraikela

Jamshedpur

Simdega

chaibasa

SINGHBHUM

PdI

O R I S S A

General of India

Buxar

W4

$P_{D}3W4/P_{U}4$

P. Sadar

$P_{U}3P_{D}4W4$

Begusarai

Barh

PATNA

MONGHY

$P_{D}3P_{U}4W4/M4$

Jehanabad

Bihar

Aurangabad

Gaya

Nawada

Jamui

GAYA

Girdih

$P_{D}2M4/P_{U}4/M_{T}4/W4$

Chatra

N

D

HAZARIBAGH

Latehar

Hazaribagh

Baghmara

D

Ranchi

nla

RANCHI

Khunti

Seraikela

CROF

$P_{U}4/W4$
$/M_{T}4$

MILES 16   0

16   0

Motihari

N

E

CHAMPARAN

Sitamarhi

P

Madhubani

$P_{D}2P_{U}4/W4$

wan

Chapra

Muzaffarpur

Darbhanga

SARAN

MUZAFFARPUR

DARBHANGA

C

$P_{D}3P_{U}$

$P_{D}4M4W4S4/B_{A}4/P_{U}4$

Samastipur

Se

Arrah

Dinapur

Hajipur

P.city

$M3W4P_{D}4$

P.Sadar

$W4$

$P_{U}3P_{D}4W4$

Begusarai

$P_{D}3W4/P_{U}4$

REFERENCE

—··—··— INTERNATIONAL BOUNDARY
——— STATE BOUNDARY
–––––– DISTRICT BOUNDARY
······· SUB-DIVISIONS
▬▬▬ ZONE
——— SUB-ZONE

MADHYA PRADESH

Gumla

Bhabua

Sasaram

SHAHABAD

Aurangabad

$P_{D3}W_4/P_{u4}$

Garhwa

Daltonganj

PALAMAU

La

$P_{D3}M_4P_{u4}O_4$

REFERENCE

—·—·— INTERNATIONAL BOUNDARY
———— STATE BOUNDARY
– – – – DISTRICT BOUNDARY
· · · · · · SUB-DIVISIONS
▬▬▬▬ ZONE
———— SUB-ZONE

Gumla

MADHYA PRADESH

Bettiah

$P_{D}2\,P_{U}4/W$
$/M_{4}/M_{T}4$

CHAM

Gopalganj

Siwan

SARAN

UTTAR PRADESH

P_{D}

Buxar

Arrah

$P_{D}3\,P_{U}4\,W_{4}$

MONTH OF MAXIMUM RAINFALL

DBH

MFP

SRS

PRN

PTN

MGH

BHG

YA

S.PAR

HAZ

DHB.

RCH

SBM

☐ JULY

AUGUST

⋮ LESS THAN 1 Cm.
JULY - AUGUST

G

N

'ar

'bganj

3

▽ Pakaur W

$1E3(A2B2)C1E3$

(034)

AS

B

$32)D1E3$

MONTH OF MAXIMUM RAINFALL

DBH

MFP

SRS

PRN

PTN

MGH

XVII

Kishanganj

Ci E3 (A4) D1 E3

B1) (003)

Purnea

E A

)D1E3

ban

Baghmara

E

W

rikela

XIV

32)DiE3

Jamshedpur

MONTH

R/

CHM

SAR

MFP

D

SHB

PTN

GYA

M

PAL

HAZ

RCH

SBM

नयमेव जयते

The coded form of each pattern consists of three
groups corresponding to the three seasons February to
May, June to September and October to January. The
central is entered in brackets.

The area covered by a rainfall pattern is termed
a zone and the zones in the map are serially numbered

Roman numbers indicate State Rainfall Zones
Three-digit figures in Arabic numerals within brackets
give their corresponding all-India equivalents.

BIHAR
AINFALL PATTERNS

S 16   0   16   32   48   64

16   0   15   32   48   64   80   96   K.METRES

P

A   L

XII   Madhubani

(058)

E3(A1B2 C1)

D1 E3

Supaul

Araria

(019)

XVI

CIE3(A3B1)

D1E3

XVII

C1E3(

(003)

IBHANGA

C1)DIE3

Darbhanga

Madhepura

SAHARSA

Purnea

PURNEA

XIV (031)

Saharsa

Begusarai   Khagaria

D1E3(A2B2)DIE3

Katihar

Bhagalpur

XIV

Ranchi

Baghmara

D₁E₃(A₂B₂)D₁E₃

$D_1E_3(A_2B_2)D_1E_3$

(031)

RANCHI

khunti

umla

(030) IX

Seraikela

$E_4(A_2B_2)D_1E_3$

chaibasa

XIV

(037) VIII

$D_1E_3(A_2B_2)D_1E_3$

-$(A_2B_1C_1)D_1E_3$

(031)

SINGHBHUM

mdega

REFERENCE

- — INTERNATIONAL **BOUNDARY**
- ⌐ STATE BOUNDARY
- ⁻ DISTRICT BOUNDARY
- ˙˙ SUB-DIVISIONS
- ◼ ZONE

O R I S S A

---

l of India.

L E G E N D

	Symbol	Rainfall interval, centimetres per month	

The coded
groups correspond
May, June to Sept
central is entere

	Symbol	Rainfall interval, centimetres per month
	A	> 30
	B	20-30
:d	C	10-20
:.	D	5-10
each	E	< 10 if the pattern begins with A or B
		< 5 if the pattern begins with C, D or E.

The area
a zone and the

Roman num!
Three-digit fi
give their correspo

RAINFA

MILES 16   0

16   0

AMPARAN

Motihari

(031)   XIV

DI E3 (A2 B2) DI E3

XII   Madhuban

(058)

(057)

DI E3 (AI B

DI E3

DI E

Gopalganj   Sitamarhi

Muzaffarpur

I SARAN

XIII   DARBHANGA

DI E3

MUZAFFARPUR

(037)

DI E3 (A2 BI CI) DI E

n   II

Darbhanga

(083)

(039)

4 (B2 C2) DI E3   IV   Hajipur

Samastipur

(065) E4

Chapra   (AI BI C2)

DI E3

Arrah   Dinapur

Begusarai

Patna

city

VI

Barh

T

IRRIGATION

CHM
SAR MFP DBH
I 4
SRS PRN
I 5
SHB PTN MGH BHG
I 2 I 1 I 3
GAYA
PAL S. PAR
HAZ
I 4 I 5
DHB
RCH
SBM

PERCENT

I_1	> 70
I_2	$50 - 70$
I_3	$30 - 50$
I_4	$10 - 30$
I_5	< 10

(030)

(037)

E4CA2

Simdega

RE

— . — INTERNA
——— STATE B
– – – DISTRIC
· · · · · SUB-DIV
▬▬▬ ZONE

Based upon Survey of India map with the permission of Surveyor General of India.

The rainfall pattern which describes the distribution of monthly rainfall throughout the year is expressed in coded form with letter symbols and numerical subscripts. A letter denotes a rainfall interval and the subscript to each letter the number of months in the interval.

E4(A1B2C1DDE3

Buxar (057)

Bhabua

SHAHABAD

VIII

(057)

E4(

Auranga

Sasaram

G

I

N E

Garhwa

Daltonganj

E4(A2 B

PALAMAU

La

MADHYA PRADESH

Gumla

(030) I

Bettiah

CHAMPARA

(031)

VI (057)

E4(A1 B2 C1)D1 E3

Gopalg

$VIII$ SARA

E4(A2 B1 C1)D1 E3

(037)

Siwan (037)

(08

E4(B2C

UTTAR PRADESH

Arrah

VI

E4(A1 B2 C1)D1 E3

Buxar (057)

END

Symbols

Cm

Cf

under   Cy

Bm

Bf

under   By

S

G

H

M

D

Ca

P

 one or more of the animals mentioned
cript which indicates the percentage
the percentages of the categories of
nen 70; each of them is also 10 per-
livestock of the subdivision/district.

Percent of total livestock

greater than   70

50-70

30-50

10-30

less than   10

G4 Cf4 Cy4

10-30 %

10-30 %

10-30%

ttle   10-30%

A

G

N

E

B

END

	Symbols
	Cm
	Cf
under	Cy
	Bm
	Bf
under	By
	S
	G
	H
	M
	D
	Ca

IS

S

shangang

Bihar

Dhanbad

DHANBAD

Baghmara

S

E

W

:ikela

Jamshedpur

LEGEND
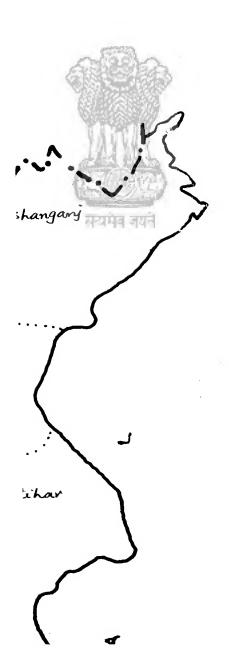
Livestock

Cattle: Males over 3 years

Females over 3 years

Youngstock 3 years and under

Buffaloes:

Males over 3 years

Females over 3 years

Young stock 3 years and under

Sheep

Goats

Horses ponies

Mules

Donkeys
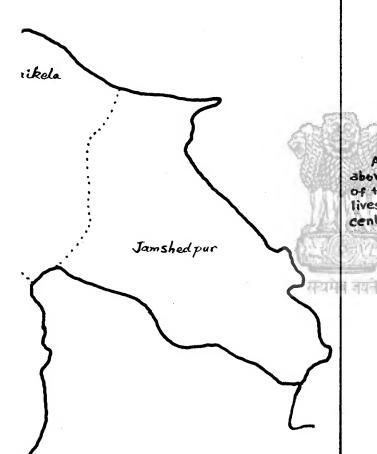
Camel

Pigs

A livestock pattern consists of one or mo
above in symbols, each with a subscript whi
of the total livestock. The total of the percer
livestock in the pattern is not less then 70; e
cent or higher of the total of the livestocl

Subscript	Percent o
1	greater H
2	
3	
4	
5	less thar
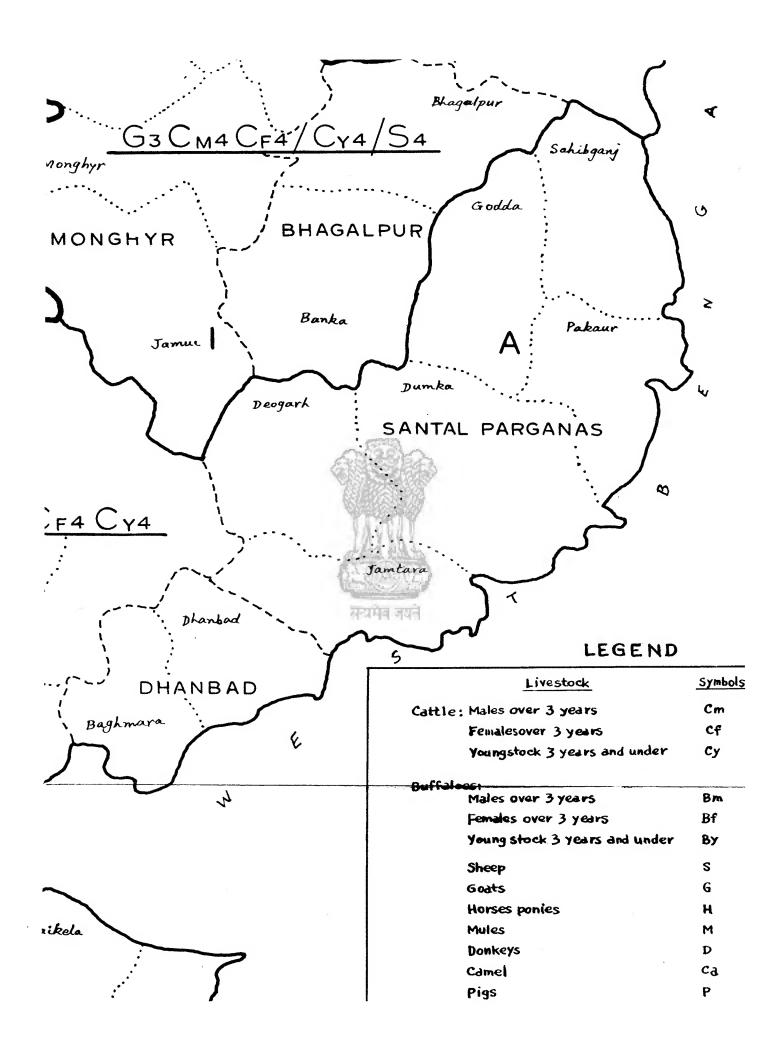
Example: Pattern: Cm_4 G_4 Cf_4 C

Cm_4	Male cattle	10
G_4	Goats	10
Cf_4	Female Cattle	10
Cy_4	Youngstock Cattle	10

G₃ C M4 C F4 / C Y4 / S4

Bhagalpur

Monghyr

Sahibganj

Godda

MONGHYR

BHAGALPUR

Banka

Jamui

Pakaur

A

Deogarh

Dumka

SANTAL PARGANAS

C F4 C Y4

Jamtara

Dhanbad

B

DHANBAD

Baghmara

S

E

W

T

rikela

LEGEND

Livestock	Symbols
Cattle: Males over 3 years	Cm
Females over 3 years	Cf
Youngstock 3 years and under	Cy
Buffaloes: Males over 3 years	Bm
Females over 3 years	Bf
Young stock 3 years and under	By
Sheep	S
Goats	G
Horses ponies	H
Mules	M
Donkeys	D
Camel	Ca
Pigs	P

BIHAR
LIVESTOCK PATTERNS

MILES   16   0   16   32   48   64

16   0   16   32   48   64   80   96   K.METRES

E

P

A

L

Madhubani

Supaul

Araria

Kishanganj

SAHARSA

BHANGA

Madhepura

Saharsa

Purnea

PURNEA

Begusarai

Khagaria

Katihar

Latehar

Hazaribagh

Baghm

Ranchi

RANCHI

Gumla

Khunti

Seraikela

G3 CM4 CF4 / CY4 / S4

Simdega

Chaibasa

SINGHBHUM

O R I S S A

eral of India

$C_{M}4 \ G_4 \ C_{F}4 \ C_{Y}4$

Barh

PATNA

Jehnabad

Bihar

Monghyr

Aurangabad

Gaya

Nawada

MONGH

GAYA

N

D

Girdih

chatra

$G_4 \ C_{M}4 \ C_{F}4 \ C_{Y}4$

AU

HAZARIBAGH

Latehar

Hazaribagh

D

Baghmar

Ranchi

Gumla

RANCHI

Khunti

Seraikela

$G_3 \ C_{M}4 \ C_{F}4 \ / \ C_{Y}4 \ / \ S_4$

CHAMPARAN

Motihari

Sitamarhi

Madhubani

iah

alganj

$G_3 C_{M4} C_{F4} / C_{Y4} / S_4$

Siwan

Muzaffarpur

SARAN

MUZAFFARPUR

Darbhanga

DARBHANGA

Chapra

Hajipur

Samastipur

H

Arrah

Dinapur

P. City

Begusarai

P. Sadar

Barh

PALAMAU

Latel

REFERENCE

- ·— ·— · INTERNATIONAL BOUNDARY
- ———— STATE BOUNDARY
- ----- DISTRICT BOUNDARY
- ·········· SUB-DIVISIONS
- ▬▬▬▬ ZONE
- ———— SUB-ZONE

Gumi

M A D H Y A   P R A D E S H

Bhabua

Sasaram

SHAHABAD

A

Garkwa

Daltonganj

PALAMAU

Lateh

REFERENCE

─ ·· ─ ·· ─ · INTERNATIONAL BOUNDARY
───────── STATE BOUNDARY
── ── ── ── DISTRICT BOUNDARY
···········› SUB-DIVISIONS
━━━━━━ ZONE
──────── SUB-ZONE

Gumla

Bettiah

C

Gopalganj

G3

Siwan

SA

UTTAR PRADESH

Buxar

A

CN